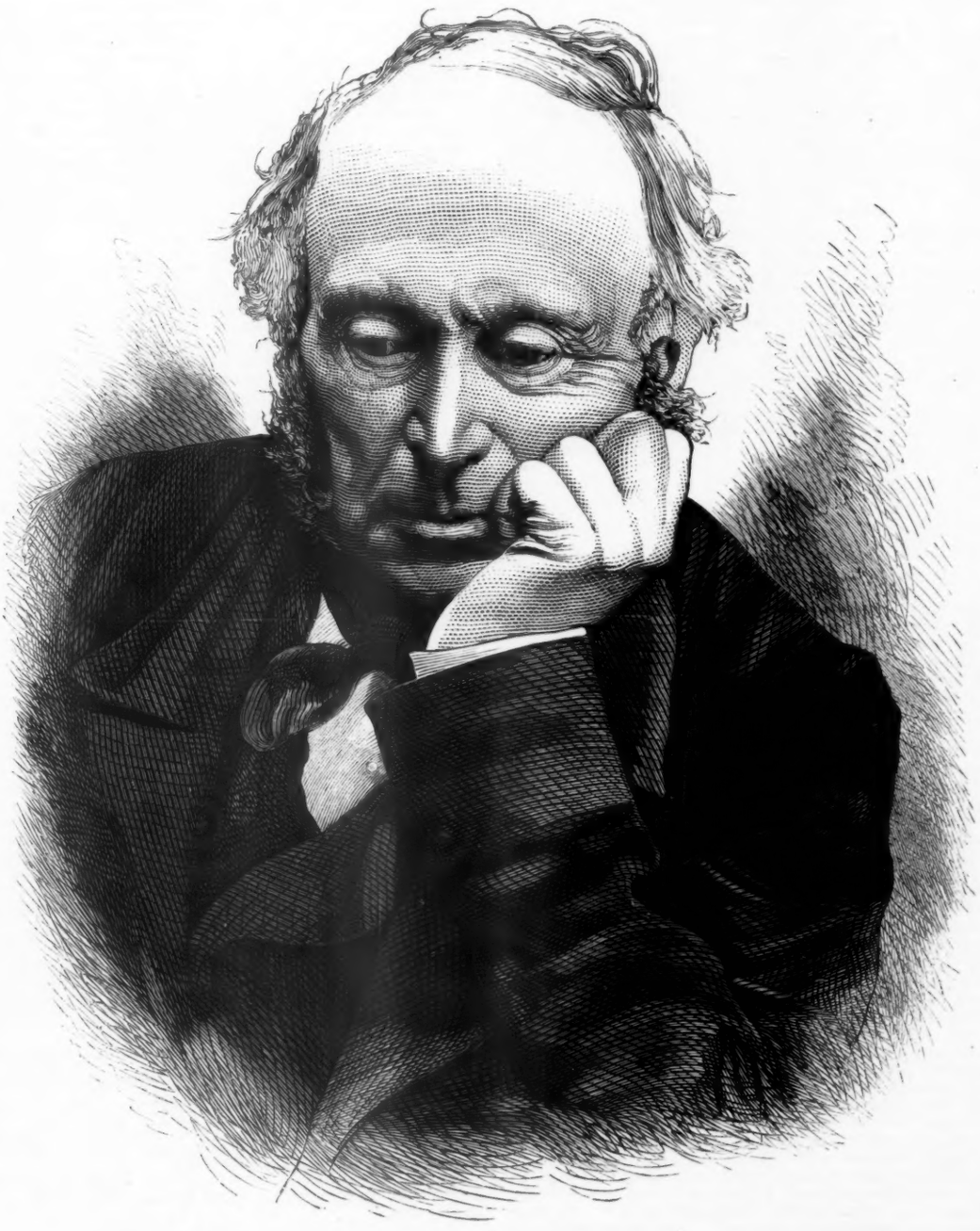
THE PRACTICAL MAGAZINE

No. 20. Vol. 4, 1874.



SIR WILLIAM G. ARMSTRONG, D.C.L., LL.D.

SIR WILLIAM G. ARMSTRONG AND THE MANUFACTURE OF ORDNANCE.

DURING the last twenty years no name has been more prominently identified with the subject of our national defences than that of Sir William G. Armstrong. To him it is largely owing that Great Britain has, in the matter of armaments, and especially of naval armaments, taken a position in advance of that occupied by any other nation in Europe. To him also it is mainly due that the science of gunnery has come to be better understood, and attained a much greater measure of importance and perfection since the time of the Russian war. Numerous rivals to the Armstrong gun have been devised; but Sir William's system, besides being at the foundation of all "built-up" guns, has held its own, without essential modification, against all competitors. It is at this moment adopted by the Governments of Italy, Spain, Turkey, Denmark, Norway, Holland, Egypt, Peru, and Chili, besides being largely introduced in Austria, Brazil, &c., and thus may be said to have world-wide recognition and renown.

Origin of the Armstrong Gun.

The attention of Sir William Armstrong was first attracted to the subject of improving the armaments of this country by the events of the Crimean war. At the battle of Inkerman, fought in November, 1854, the British troops turned the tide of victory against the Russians by the fire of a couple of 18-pounder guns which, at a late hour, and by infinite exertions, were brought to operate on the ranks of the enemy. It was generally acknowledged that the victory then won by the British troops was due to the superior range of these two guns; and when Sir William applied himself to the consideration of the difficulties experienced in bringing such heavy guns into action, he commenced to calculate on the probabilities of bringing lighter ordnance to operate at an equally long range. Seeing that the plan of rifling small arms had been very successful, he did not see why an equal measure of success should not be obtained in cannon; and he further calculated that if wrought iron were used instead of cast iron in the manufacture of ordnance, a great saving of weight would result.

With these thoughts passing through his mind, Sir William set about the preparation of a design of a light wrought-iron gun. Through the assistance of Mr. Rendel, the well-known engineer, the inventor obtained an interview with the Duke of Newcastle, then Minister of War, to whom he submitted a plan of his proposed new gun, and explained the objects he had specially in view. The Minister of War, favourably impressed with the ideas laid down by Sir William, and appreciating to their full extent the benefits sought to be attained, gave his sanction to the construction of one gun for experimental purposes. In pursuance of this commission, Sir William proceeded to make his gun in December, 1854, and it was finished in April, 1855; but it was not until the beginning of the following year that the gun was submitted to the inspection of the Government authorities. The inventor, solicitous to avoid the chance of failure, took every precaution to make his gun as perfect as possible. He made experiments with it for fully twelve months previous to its being submitted to the Government, under all possible circumstances. If they could be written, these experiments would probably prove as instructive and interesting a chapter of biography as ever was penned. To avoid accident, as well, probably, as for more politic reasons, he was accustomed to test his new form of ordnance in the most out-of-the-way places, and at the most untimely hours. Not unfrequently he would have it carried to the Allenheads Moors, a lonely and desolate district in Northumberland, inhabited only by lead miners and a few small farmers, and situated fully 2,000 ft. above the level of the sea. In the summer time he preferred to carry his gun to the coast, where he carried on his experiments between the hours of three and six in the morning, stealing away, after people began to stir about, almost like a guilty thief, in order to avoid public interruption and observation. At last, when the results obtained were such as to satisfy himself that he had mastered the problem he sought to solve, Sir William, in the beginning of 1856, brought his invention under the notice of the War Department; but the functionaries then connected with this important branch of the administration, did not at first receive the inventor with much favour. The gun which he submitted to their inspection was of very small size, being only a 3-pounder, so that it almost justified the derision with which they assailed it when they spoke of it as a "mere pop-gun."

Determined not to be baulked, Sir William persevered in the face of disappointment, and when he next submitted to the Government a gun intended for a 5-lb. projectile he was received with more consideration. The results obtained by this gun were such as to satisfy the War Office authorities that it owned some merit. They therefore gave him a commission to make an 18-pounder gun, on the same principle. When completed, this gun was exposed to a series of searching trials by the Rifle Cannon Committee, appointed in 1857; and it stood all tests in such a satisfactory manner, as to induce a perfect faith in its superiority over all other guns in the service. When the report of the Committee was presented to Government, the War Office at once took steps to treat with the inventor for the use of his patent. General Peel, who was then Minister of War, had more than once declared Sir William's invention to be such, that Government must have given the inventor any compensation he liked to name. But Sir William chose the honour rather than the emoluments of his invention, and executed a deed transferring to the Government all his patent rights free of any charge. As an acknowledgment of such patriotic conduct, the Government created for the inventor the new office of Engineer of Rifled Ordnance, with a salary of £2,000 per annum. In this position he was entrusted with the practical superintendence of the Ordnance Department, and more especially of that part of it set apart for the manufacture of his own guns. As a further recognition of his valuable invention, he was made a Companion of the Bath, and received the honour of knighthood.

Description of the Armstrong Gun.

In making his experiments in gunnery, Sir William Armstrong was struck by the facility with which steel or wrought-iron guns might be made by simply forging the material into the required form, and boring it in the usual manner. With this view a number of cylinders were forged, each 12 inches long and 5 inches in outward diameter. These were bored to an internal diameter of $1\frac{3}{4}$ inches and tested in the following manner. Each cylinder was entirely filled with gunpowder and the open end was pressed by screws against a very thick iron tube bored to the same diameter, and containing a cylindrical shot of lead equal in weight to about three spherical shot of the same diameter and material. Several of the cylinders burst on the first discharge, and those which remained uninjured were afterwards reduced in thickness and tested a second time. If they still resisted the explosion the thickness was further diminished, and this mode of proceeding was continued until fracture took place in all of them. Consequent upon the uncertainty in the strength of the material, and the impossibility of defining the thickness necessary to resist a given charge of powder, Sir William was compelled to dismiss this mode of construction. He next applied steel as an internal lining, and tried to obtain the necessary strength by encircling it with twisted cylinders of wrought iron, tightly contracted upon the steel core, by the usual process, and cooling after previous expansion by heat. By this means he succeeded in completing a gun which gave perfect satisfaction. At the last meeting held by the British Association in Newcastle, Sir William thus described the original and earliest form of the Armstrong gun:—

"The gun, when fired, recoils upon an ascending slide without displacing the carriage, and then returns to its place by gravity. The slide frame turns upon a pivot, which permits the gun to be pointed to either side without moving the carriage. The gun is elevated or depressed by means of a screw which is fixed to the movers with the slide, and a similar screw is applied for the transversing or horizontal movement.

The arrangement for loading at the breech may be described as follows:—At the back end of the gun a powerful screw is applied, having a hole through the centre, forming a prolongation of the bore, and through which the bullet and charge are delivered into the gun. A 'breech pipe' with a mitred face, fitting a similar face at the end of the bore, is then dropped into a recess, and by the action of the screw, pressed tightly into its seat so as effectually to close the bore.

In order to facilitate the loading, the bullet and cartridge are placed in a tube, from which they are thrust into the gun by means of a rammer.

The breech-piece contains the vent, with a cavity for receiving a small quantity of powder to ignite the charge; and as the breech-piece is prepared for firing while the gun is being loaded, no time is lost in subsequent priming.

Several of these breech-pieces accompany the gun, some being arranged to fire by percussion-caps, and others by friction-tubes or port-fires.

The bore of the gun is $1\frac{3}{4}$ inches in diameter, and contains eight spiral grooves having an inclination equal to one turn in 12 ft. These grooves terminate at a distance of 14 inches from the breech, and the bore then gradually expands, in a length of

3 inches, from $1\frac{3}{4}$ inches to $1\frac{7}{8}$ inches in diameter. The bullet, in the operation of loading, passes freely through this widened space; but its diameter being a little in excess of the bore, it lodges in the tapered contraction at the commencement of the grooves.

The mode in which the gun is made up of separate parts consists in surrounding the steel centre with twisted cylinders of wrought iron, made in a similar manner to gun barrels, and, being shrunk upon the steel, they are in that state of initial tension which is necessary to bring their entire strength into operation.

The weight of the gun by itself is about 5 cwts.; but, including the carriage, its weight is nearly identical with that of a light 6-pounder, with its carriage complete. It is probably heavier than necessary, but recoil might be inconveniently increased if the weight were much reduced."

Having described the gun and its carriage, Sir William spoke of the projectile as follows:—

"The resistance which a projectile encounters in passing through the air is mainly dependent upon the area of its cross section, and the advantage of lengthening a bullet consists in augmenting the weight without increasing this sectional area; but in order to realise this advantage, it is essential that the bullet be guided endways in its course, and this can only be effected by causing it to rotate rapidly upon its longer axis, which is accomplished by firing it from a rifled bore.

This peculiar influence of rotation, in giving persistency of direction to the axis of a projectile, is entirely distinct from that which it also possesses of correcting the tendency to aberration arising from irregular form or density; and in order to investigate experimentally the nature of this action, I constructed an apparatus by which a cylindrical bullet could be put into extremely rapid rotation, and be then suspended in any direction.

When thus suspended, the rotating bullet exhibited the same remarkable properties as are possessed by the revolving disc in the recently-invented instrument called the 'gyroscope.' When pressure was applied to either end of the axis, the movement which took place was not in the direction of the pressure, but at right angles to it. Thus a vertical pressure deflected the axis horizontally, while lateral pressure deflected it vertically, but the most important point elicited was this, that the time required to produce these indirect movements became greater as the velocity was increased, and consequently that the amount of deflection produced in a given time by a given pressure, diminished as the rotation was accelerated."

With a 3-pound pointed bullet, and charges of 12 ounces of powder, the following were the

RANGES WITH THE ARMSTRONG RIFLED GUN.

Elevation.	Range in yards.	
¼°	408	Measured to first graze upon a plane about 5 ft. below the centre of the gun.
1°	770	
2°	1,112	
3°	1,500	
4°	1,840	
5°	2,056	
6°	2,300	
7°	2,600	

When the gun had more elevation than 7°, the bullets could only be fired out to sea, and the range could not be ascertained. By way of comparison with these results, Sir William quoted to the British Association the following extract from Sir H. Douglas's "Naval Gunnery," specifying the ranges obtained with a 68-pounder, throwing shot with full charges:—

RANGES WITH A 68-POUNDER.

Elevation.	Range in yards.
¼°	340
1°	833
2°	1,247
3°	1,558
4°	1,737
5°	2,035
6°	2,307
7°	2,440

By means of a ballistic pendulum, Sir William found that when fired with charges of 13 ounces of powder, a 3-pound bullet passed through 2 ft. 2 in. of hard elm timber, and flattened against a cast-iron block, forming the back of the pendulum, the initial velocity being about 1,550 ft. per second.

SIR WILLIAM'S NEW PROJECTILE.

From this time forward Sir William gave his almost undivided attention to the perfecting of the science of gunnery. It had hitherto been the practice to bring into the field three kinds of projectiles. These were—

Solid round shot.
Shrapnel shell.
Canister shot.

As its name implies, the first of these was simply a solid sphere of cast iron. The second was a shell containing leaden bullets, with a small bursting charge, and fitted with a time-fuse, ignited by a flash in the gun, so as to explode the shell a short distance in front of the object aimed at. The third variety consisted of a number of small iron balls, enclosed in a thin canister, and designed for firing upon the enemy at a very short distance.

Both the round shot and the shell were very uncertain in their action, and could scarcely be used with effect at more than 1,000 yards. There was, moreover, apart from their defects, the obvious disadvantage of having three varieties to carry into the field of action, because, after exhausting the kind most suitable for any particular service, it became necessary to use a kind not perhaps adapted for the purpose to be served. It was under these circumstances that Sir William Armstrong, to use his own words, "conceived the idea of constructing a projectile which might be used either as a solid shot, as a shrapnel shot, or as a canister shot, and which should also have the advantage of exploding by impact as well as by the action of a time fuse. The projectile consisted of a very thin-cased iron shell, the interior of which was composed of forty-two segment-shaped pieces of cast iron, built up in layers around a cylindrical cavity in the centre, which contained the bursting charge and the concussion arrangement. The exterior of the shell was thinly coated with lead, which was applied by placing the shell in a mould, and pouring molten lead around it. The lead was also allowed to percolate amongst the segments, so as to fill up the interstices, the central cavity being kept open by the insertion of a steel core. In this state the projectile was so compact that it might be fired through six feet of hard timber without injury, while its resistance to the bursting force was so small that less than one ounce of powder was enough to break it in pieces. When this projectile was to be used as a shot it required no preparation." One of these terrible missiles had been compressed in a close chamber, where the pieces could be collected; and it was found that they consisted of 106 pieces of cast iron, 99 pieces of lead, and 12 pieces of fuse, making altogether 217 pieces. It is not the first time that one of these shells has made 100 holes in a column at a distance of 3,000 yards.

SIR WILLIAM ARMSTRONG'S FUSE.

At a meeting of the Institution of Civil Engineers, held during the Session 1860-1, Sir William Armstrong described his new fuse adapted for the sea service shells of rifled ordnance. In the percussion fuse for both sea and land service it was necessary that the fuse should be so constructed as to resist explosion under the greatest amount of violence to which it might chance to be exposed in transport or handling; but at the same time the construction had to be such that the act of firing the shell from the gun should have the effect of putting the fuse from half cock to full cock, thus giving it a sensibility which it did not previously possess. There was, however, this important difference in the two cases. In the land service fuse the sensibility thus acquired could not be too great, but in the sea service fuse the sensibility must be limited, because a considerable portion of the shells would ricochet from the water, and if they were to explode from that concussion, the chance of their subsequently striking the ship would be lost. And the important object in the sea service fuse was to attain the greatest possible rapidity of action, so that the explosion might take place either in the act of passing through the timber or instantly on entering the ship. Sir William's sea service fuse had been designed with a view to the attainment of these objects, and had been termed the pillar fuse. It consisted of an external case, screwed to fit the shell, and containing a central pillar, with a hole through it, filled with powder, and tipped at the upper extremity with a detonating composition. This extremity projected into a cavity in the cover, a clearance being left of about half a tenth of an inch all round the detonator. If the pillar were to move forward on to one side the detonator would explode by striking on the one case against the top, and in the other case against the side of the cavity. It was therefore necessary to secure the pillar in its central position in order to be perfectly safe in transport and in handling. This was affected by applying a leaden hoop, called a guard, which filled up the space around the pillar, and prevented any lateral movement. A hoop also rested on a collar in the pillar by means of a flange, and abutted at the upper end against the cover, thus preventing any longitudinal movement. In fact until the guard was dislodged the pillar did not admit of any movement whatever. This then was

the condition of the fuse before the gun was fired, and in that condition it was capable of resisting any amount of accidental violence to which it might chance to be exposed. But when it was fired from the gun the motion communicated to the shell was so rapid and sudden that the *vis inertiæ* of the guard caused the flange to be stripped off, the guard itself being lodged at the bottom of the fuse. In this condition, although the pillar would have lost the support of the guard, it would still derive support from a little leaden cup, which was called the regulator, because by increasing or diminishing the thickness of the cup the sensibility of the fuse was regulated to the required degree. The action obtained by this arrangement of fuse was extremely rapid, because the amount of movement in the pillar was extremely small; and also because the detonator was in immediate contact with the priming powder in the pillar, and a strong jet of flame was instantly shot from the fuse into the shell. So rapid was the action that, in firing a 100-pounder shell against a butt 18 in. thick, the shells were compressed in the act of passing through the timber, and the shattering effects produced were most destructive.

Government Reports on the Armstrong Ordnance.

In 1858, on the recommendation of General Peel, the then Minister of War, a Select Committee was appointed "to advise him as to what was the best rifled gun for field service." This Committee, after going into the matter, came to the conclusion "that it was not expedient to incur the expense of trying further experiments with any gun except those of Whitworth and Armstrong." The Committee therefore proceeded to make experiments with these guns only. The Committee go on to say, "it appears that the experiments with the Whitworth gun were not of such an extended character as those with the Armstrong gun." At the time Mr. Whitworth had not any gun of his own construction, nor did he propose any system of constructing guns. He had only rifled blocks of brass and cast iron. The system of Armstrong was therefore the only complete one before the Committee. On the other hand, Mr. Armstrong proposed a plan of constructing a gun which rendered it capable of enduring the strain to which rifled ordnance is submitted. This method was certainly at the time the only one capable of fulfilling this condition. The Committee therefore found, "that at this moment no other method of constructing rifled ordnance exists which can be compared with that of Mr. Armstrong." In combination with his system of the construction or manufacture of guns Sir William had introduced to the notice of the Government, the plan of breech-loading a gun, being rifled on the old polygroove system, which involved the cutting of the projectile with soft metal; and this combination of breech-loading, rifling, and cutting the projectile with soft metal, came to be known all over the world as the Armstrong system. The range and precision of the Armstrong gun were so much superior to all field ordnance known at the time, that after careful and repeated trials, the Committee appointed to investigate the question recommended its adoption as the field gun of the service. "Your Committee are of opinion that the adoption of the Armstrong gun by the Secretary of State for War, for special service in the field, was fully justified." The Commander-in-Chief also gave it as his opinion that "Sir William Armstrong's system surpasses in completeness any other." Colonel Bingham, the Adjutant-General of Artillery, declared himself perfectly satisfied that the Armstrong field gun "is the best gun known, and that this is the general opinion of the officers of artillery of all classes."

Objections have been made against the Armstrong breech loader, as being liable to injury from use, the works being, it was alleged, too delicate to stand the rough handling inevitable in the field. But the officers who commanded the Armstrong batteries in China during the operations there in 1862-3, found no difficulty in keeping the guns in order in all weathers and under all circumstances. They have been equally successful in the New Zealand and subsequent wars undertaken by Great Britain.

The advantages of breech-loading have thus been stated by Sir William Armstrong himself:—

"1. It permits of a bullet being used of a larger diameter than the bore, by means of which accuracy of fit is secured, and the material of the bullet is forced into the grooves of the bore.

2. Any ignited matter remaining in the gun after firing may with ease and certainty be removed, or if left in the gun, it will be thrust forward from the part where its presence would be dangerous by the insertion of the succeeding bullet.

3. In the Armstrong breech-loader, the perishable part of the gun, viz., the vent and its vicinity, is comprised in the movable breech piece, which may easily be repaired when worn or otherwise injured.

4. A rifled gun, loaded at the breech, may be more rapidly fired than a rifled gun loaded at the muzzle, because the fouling of the bore permits no impediment to the insertion of the bullet, when introduced from behind."

Sir W. Armstrong has, however, from a very early date, identified himself with muzzle-loading ordnance. Indeed, for larger guns, he has undoubtedly preferred the muzzle-loading system. His first heavy guns were muzzle-loading guns rifled in a peculiar manner, to enable the projectile to enter easily from the muzzle, but to leave the gun on discharge perfectly fitting, and therefore steady. This system of rifling is styled the "shunt" rifling, and has been very largely adopted in our own and other services. Beginning with a 70-pounder, Sir William rapidly advanced to 120-pounder and 200-pounder muzzle-loaders, and by the year 1864 had achieved the production of "Big Will," a 600-pounder gun of 23 tons weight, which, after firing over 200 rounds, is now mounted in the defences of Portsmouth. Thus in seven years Sir William multiplied the power and weight of his ordnance one hundredfold. The ten subsequent years have witnessed great advances in gunnery, but none so wonderful as the earlier period. Yet at this moment Sir William is undertaking the manufacture of 100-ton guns at the Elswick Works, and there seems practically no limit to the development of ordnance upon Sir William's system of construction.

Sir William Armstrong as a Hydraulic Engineer.

As every engineer must be aware, the science of hydraulics owes more to Sir W. Armstrong than to any other living man. His adaptation of water as a prime mover has a curious and interesting history. It is related that his attention was first directed to this subject in the year 1835. He was then making an excursion in a mountainous district of Yorkshire, and a streamlet rushing impetuously towards the sea struck him as possessing much latent power which might be profitably utilized for industrial and commercial ends. In 1845, not less than ten years afterwards, a scheme was projected for supplying Newcastle with water from Whittle Dean. Of this scheme Sir William was the chief promoter, having been instructed to act as solicitor to the Company formed for the purpose of carrying it out. In this capacity he was afforded an opportunity of putting into operation the idea suggested to his mind ten years previously by the wasteful current of the little Yorkshire streamlet. He had previous to this time invented his hydraulic crane, of which a model had been exhibited to the Literary and the Philosophical Society of Newcastle-on-Tyne. A full sized crane was now made and fitted up on the quay side at Newcastle, the pressure from the water pipes of the Whittle Dean Company being employed as a motive power. This experiment resulted in complete success; and the Armstrong crane was thenceforward to rank as one of the great economizers of human labour.

But this rank was not to be attained without some little trouble. Like all other inventors, Sir William had to conquer prejudice and ignorance before he reached the full fruition of his labours. The experimental crane erected on Newcastle Quay became the cynosure of engineers from all parts of the country. It was introduced in the construction of the Liverpool Docks by Mr. Hartley, the engineer of the North Docks there. A good story is told of the circumstances attending its application to the work of constructing the Liverpool Docks. The attention of Mr. Hartley was first directed to the crane by Sir William Cubitt, the well-known contractor. Disposed at first to discredit what he heard of the wonderful powers of the Armstrong crane, Mr. Hartley nevertheless resolved on visiting Newcastle and satisfying himself as to its capabilities. Arrived on the Newcastle Quay, he found the crane lifting hogsheads from the hold of a ship. After watching with astonishment the swift and graceful movements of the crane as it hoisted up the casks with great rapidity from the hold of the vessel, and then, after swinging round, deposited them carefully on the quay, Mr. Hartley turned to the crane keeper, who was known by the *sobriquet* of "Hydraulic Jack," and said:—

"You have got a queer machine there; where are all the wheels?"

"There are none," was the reply.

"But what makes it move, then?"

"It goes by water underground," said Jack.

"Do you ever let a hogshead fall?" asked Mr. Hartley.

"Oh yes!" was the reply; "but I picks it up before it touches the ground."

"You are not clever enough for that," said Mr. Hartley, whose credulity in the power of the crane was still very limited. But Jack had not reckoned without his host, so in his canny Northumbrian way he asked,—

"What will you stand if I show you?"

Whether Jack and his interrogator came to an understanding as to the guerdon dependent on this operation being performed, the story does not say; but at any rate Jack proceeded to carry out his undertaking in the following way:—Running up a hogshead to the highest point of the crane, he let it down with a rush that threatened to crush the cask into atoms at the bottom; but Jack knew the power of the crane, and so dexterously checked the speed of the hogshead, that it stopped at barely an inch from the ground. The narrator of this ancedote (which first appeared in the columns of the Newcastle "Daily Chronicle") adds that "Mr. Hartley was convinced, went directly to the inventor, told him he had seen the crane, and that it was just the thing he wanted."

The principle of the hydraulic crane has been very much extended by Sir William Armstrong since the occurrence of this incident. One of his first inventions in hydraulic engineering was the hydro-electric machine, which is said to be one of the most powerful means of producing frictional electricity that has ever been devised. The invention of this machine was suggested by a circumstance as simple and as curious as that of the apple falling from the tree, which led to Sir Isaac Newton's discovery of the law of gravitation, or that of the singing of the tea-kettle, which suggested to Watt the conception of the steam-engine. While on a visit to Cramlington Colliery in Northumberland in 1840, Sir William observed that a jet of steam was escaping from a fissure in some cement of chalk and oil, placed round the safety valve of a steam boiler. The jet of steam was found to electrify any one who came into contact with it. Sir William carefully applied his mind to the investigation of this phenomenon, and published the results of his inquiries in the "London Philosophical Magazine." The hydro-electric machine which he invented from this incident was much praised by scientific men both at home and abroad, and at the Polytechnic Institution in London, where it was for some time exhibited, it attracted a good deal of attention. In recognition of his researches and discoveries in hydro-electricity Sir William was elected a Fellow of the Royal Society.

Originally Sir William's principle of the hydraulic crane was defective in this important respect, that the natural head gained by altitude was essential to put the crane in motion. Hence the power of the crane could only be employed in a position situated below the point where the water was accumulated. One of the first improvements introduced by the inventor was, therefore, the substitution of an artificial head or accumulator for the natural head gained by altitude, thus making the application of hydraulic power practicable in all situations. To this improvement the Armstrong crane has owed much of its value, for the circumstances in which a natural head could be applied were comparatively rare. Armstrong cranes are now to be found in all parts of the world, applied to all manner of purposes; and Sir William has so extended his principle as to make it embrace other machines besides hydraulic cranes. In the north of England, his system of hydraulic hoists has been applied to many of the principal ironworks, including those of Clarence and Ferryhill. Although this hoist has been before the world for a number of years, it still holds its own against all rivals. It consists of a strong framework of six columns, connected together by wrought iron bracings, and by girders at the top. Two cages, 10 ft. by 9 ft. 3 in. move up and down in this frame, and are connected together by a wire rope, passing over a sheave, so that when one is at the top the other is at the bottom. These cages in ascending and descending therefore move in contrary directions, and being of equal weight balance each other.

The motive power for lifting each cage is independent, and consists of two inverted hydraulic cylinders, placed one on each side at the bottom of the framework. The rams in these cylinders are each 11¾ in. in diameter, and have a stroke equal to one-tenth of the total lift, or 8 ft. The chain is fastened at one end to the cylinder, and reeves over a five-sheaved block at the end of the ram, and a fixed four-sheaved block at the top of the cylinder, and thence over two sheaves at the top of the framework to the same shackle-plate, on the centre of each cage, to which the wire ropes already referred to are attached. When the pressure is admitted into the right hand cylinder the ram descends, and the chain, being multiplied in its speed and range ten times by the block arrangement, lifts the right hand cage to the height required. The left hand cage descends of its own weight, and is made sufficiently heavy to pull up the ram and exhaust the water in the left-hand cylinder. The water pressure is supplied from a pair of accumulators, the water being forced into them at a pressure of 700 lbs. per square inch by a pair of steam-engines 14 in. diameter of cylinder, and 18 in. stroke, working the pumps direct from the piston-rods. These engines are always at work raising the accumulators, except when they are at the limits of their stroke, when a self-acting throttle stops the engine, until by the working of the hoist the accumulator ram descends, and re-opens the throttled valve of the engine. The chief advantages claimed for Sir William Armstrong's blast furnace hoists are safety combined with uniform steadiness and smoothness of action. The economical results of the use of the Armstrong hoist have been thus put by a well known Cleveland engineer: "a cylinder full of water at 700 lbs. pressure is required to raise the load, the average weight of which (exclusive of barrows, which balance each other) is two tons. The power exerted in filling a cylinder 11¾ in. diameter 8 ft. long, with water at 700 lbs. per square inch, is equal to raising an equal weight of water, *i. e.* 375 lbs., to a height of 1613 ft., the corresponding head of 700 lbs. pressure.

$$375 \times 1613 = 604{,}875 \text{ foot pounds exerted.}$$

The power resulting is two tons, or 4,480 lbs. raised 80 ft. = 358,400, or a difference of 246,475 foot pounds." It has been argued that on account of the Armstrong hoist using the same-sized cylinder full of water for any and every load lifted, and also from the great amount of friction generated by its mode of working, a large percentage of the effective power of the coal is consumed; but the advantage of the Armstrong hoist in other respects are such as to lead to its preference over other hoists that may be more economical in the expenditure of power. Sir William Armstrong's hydraulic machines have been applied to many, and indeed we might add to all purposes for which mechanical power is necessary. They have been used for lifting ore from lead and other mines, for the transmission of waggons in a colliery, for pumping water from shafts, for opening sluice gates, for turning swing bridges; and although infinite progress has been made in the perfection of hydraulic engineering since Sir William's first crane was erected on Newcastle Quay, the name of Armstrong has been and is likely to continue to be more prominently identified with hydraulics than any other.

The Elswick Works.

The Elswick Works, at Newcastle-on-Tyne, belonging to Messrs. Sir W. G. Armstrong and Co., employ between 3,000 and 4,000 workmen. They are situated on the banks of the River Tyne, having a river frontage of nearly three quarters of a mile in length. On the other side they are bounded by the Newcastle and Carlisle railway, branches from which extend into the works. They are thus in immediate communication with the entire railway system of England, and can also ship their products direct to all parts of the world. The workshops and works occupy an area of about forty acres.

Steam engines of a total of 2,000 horse power are employed in the works, in addition to three small locomotives; and the total consumption of fuel for all purposes averages 300 tons per day. The workshops are amply fitted with a collection of machine tools, embracing some of the most powerful lathes, slotting, planing, and boring machines yet made, in addition to a large assortment of tools specially designed for the manufacture of rifled ordnance on Sir William Armstrong's coil system.

A new forge shop of very unusual dimensions has just been completed; it is fitted with the most powerful steam hammer yet made in England, and with four powerful hydraulic cranes, designed to meet the requirements of the manufacture of ordnance up to 100 tons weight.

A new wharf fitted with a set of sheers capable of lifting weights of 100 tons, for the loading or discharging of pieces of machinery, ordnance, or forgings of the heaviest description, is now nearly completed.

The following are the principal manufactures of this establishment:—

I. Hydraulic machinery of all descriptions, such as lifting cranes and hoists for wharves, railway warehouses, docks, &c. Amongst the chief works of this class made at Elswick may be noted the 100-ton crane erected at Barrow docks, the 80-ton cranes in course of erection at Woolwich and Newcastle; the coal-discharging plant erected for Messrs. Cory and Co. in London, where the screw colliers are discharged at the rate of 800 tons per hour; and the cranes and other hydraulic appliances at the St. Pancras Goods Station of the Midland Railway in London. This hydraulic machinery is in use at nearly every large railway station in England, Ireland and Scotland, and at the various docks in London, Liverpool, Hull, Grimsby, Newport, Cardiff, Swansea, &c. It has formed the exclusive *spécialité* of the firm ever since the first introduction of the hydraulic system by Sir W. G. Armstrong in 1845.

II. Steam boilers and steam engines of all sizes for pumping and other purposes.

III. All kinds of wrought-iron bridge work, and especially hydraulic swing bridges. Amongst the latter may be noted the railway bridge over the river Ouse near Hull, with two opening spans of 100 feet each, and the new swing bridge now in course

of erection over the river Tyne, at Newcastle, of which the swinging portion weighs upwards of 1,500 tons.

IV. Wrought-iron rifled ordnance on Sir W. G. Armstrong's coil system, of all sizes, from field guns up to heavy ordnance of eighty tons weight per gun. Guns manufactured by the firm have been supplied to the British Government both for the army and navy, and also to almost every other government in the world.

V. Gun carriages and arrangements of every kind for mounting guns of all calibres, whether for land or naval defences, including the recently introduced arrangements for working and loading heavy guns by hydraulic machinery, now being applied in Her Majesty's navy.

VI. All descriptions of ammunition, including shot and shell of various kinds, Palliser chilled projectiles for penetrating armour plates, fuses of various descriptions, friction tubes, magazine fittings. The firm also supply "pebble" and R. L. G. powder made to the specification of, and subject to the tests imposed by Her Majesty's Government, along with small arms and all fittings required for the complete equipment of ships of war.

VII. They also supply gunboats of the "Staunch" class (designed and introduced by Mr. Geo. Rendel), complete with all their equipment.

VIII. Mechanical and electrical torpedoes and all the apparatus connected therewith, including complete plans for the defence of harbours, river entrances, straits, &c.

IX. Gatling guns or mitrailleuses, and their special ammunition.

X. Cast-iron of a high quality known as the "Ridsdale" and "B. Ridsdale" pig-iron; also pig-iron for the manufacture of Bessemer steel. The "Ridsdale" and "B. Ridsdale" pig-irons are largely used at Woolwich for the manufacture of armour piercing projectiles, and other purposes. They are also used in the manufacture of bars and plates of a quality equal to the best Yorkshire brands. The foundry is capable of turning out castings of the largest size, such as cylinders and framings for marine engines, columns, girders, pipes, and general foundry work. The forge is capable of producing marine engine and screw shafts of the largest size, and all descriptions of forged work. The Ordnance works are capable of turning out from sixty to eighty tons of finished guns every week.

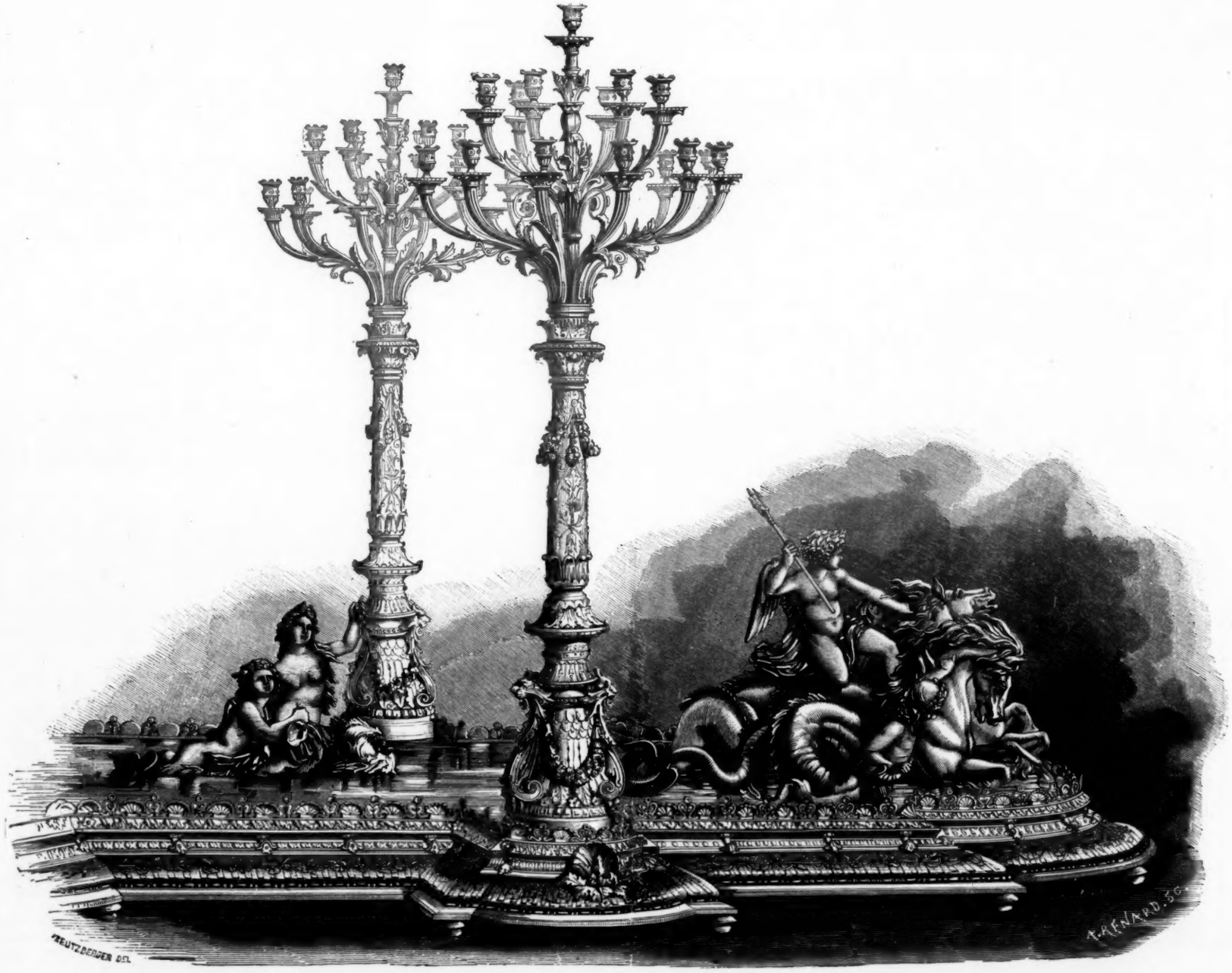
General Biographical Notice of Sir William Armstrong.

Sir William Armstrong was born at Newcastle-on-Tyne in 1810. His father belonged to Wreay, a small town in Cumberland, and came to Newcastle at the instance of Mr. William Losh, a partner in the then well known firm of Losh, Lubbrin and Co. By this firm the elder Armstrong was for some years employed as a clerk, and ultimately he succeeded to the business. He was noted as a man who possessed more than usual ability, and took a prominent interest in public affairs, being at one time Mayor of Newcastle. The distinguished son of this gentleman showed an aptitude for the study of mechanics from his sixth year, when he was accustomed to employ himself in setting a number of old spinning wheels in motion by means of weights descending on springs from the top to the bottom of his father's house, and these wheels he made to represent the operations of pumping water and grinding corn. When his father had removed to Newcastle, he became very intimate with a well-known and highly-respected solicitor of the name of Donkin, to whom in due course Sir William was apprenticed, with a view to following the profession of a lawyer. When he had completed the term of his apprenticeship, and after having studied in the chamber of his brother-in-law, Mr. Watson, then a special pleader, and afterwards a Baron of the Exchequer, he qualified as an attorney in London, and then returned to Newcastle to join the firm as a partner. For a number of years afterwards the firm was carried on under the name of Donkin, Stable and Armstrong. Having developed his genius for mechanics as he advanced in life, Sir William resolved to abandon the law and to become in practice what he was in reality, a mechanical engineer. In 1847 he became associated with Mr. Donkin, Mr. Potter and Mr. Cruddas in the establishment of the Elswick Engine Works at Newcastle-on-Tyne. These works have now attained to a world-wide celebrity; but at that time they were on a very small scale, and the firm had a hard struggle during the first two or three years of its existence, to keep its head above water. But the genius of Sir William soon made the firm known; and when the Armstrong gun made its appearance, an extension of the Elswick Works were laid out specially for the manufacture of this kind of ordnance. This was done at the sole risk of the proprietors; but after the success of the Armstrong gun was admitted by the leading authorities of the day, the Government of Lord Derby entered into a contract with the Elswick Company for the manufacture of guns on the Armstrong principle. Indeed, it may be said that the Government had no other alternative, because the Royal Gun Factory at Woolwich had neither the machinery nor the experience adapted to the requirements of Sir William's great invention. When he was appointed Engineer of Rifled Ordnance and Superintendent of the Royal Rifle Gun Factory for Rifled Ordnance, Sir William abandoned his proprietary connection with the Elswick Works; and although it was frequently alleged that his partnership in that concern disqualified him from holding office under the Government, Sir William expressly repudiated, on more than one occasion, that there was any such disqualification. The contract with the Elswick Company provided that they should find the works and plant at their sole expense for the sole use of Government; and that Government should employ the plant, or, in default, pay such compensation as should in case of difference be fixed by the Attorney-General. The contract of the Government with the Elswick Company terminated in 1863, when the Company received an absolute sum of £65,000 as compensation for the expenditure incurred in works and plant; and Sir William, having in the same year resigned his appointment as Engineer of Rifled Ordnance, he again joined the Elswick Company as principal partner, in which capacity he still continues.

Although he has not courted public life and its distinctions, Sir William is well known as a man of science, and his speeches on all public occasions have been listened to with the greatest deference and respect. There is nothing common-place or namby-pamby about what he has to say. He never essays to speak unless he has something worth speaking about, and what he has to say is said in the best possible way, and in the way most calculated to arrest attention and produce the desired effect. Greater praise than this it would be difficult to bestow on any man, but of no man can it be spoken more truly than of Sir William Armstrong.

In presiding over the Newcastle meeting of the British Association, in 1863, Sir William called attention to the probable extent and duration of the coal fields of the United Kingdom. Premising that we had already drawn from our choicest mines a far larger quantity of coal than had been raised in all other parts of the world put together, and that the time was not remote when we should have to encounter the disadvantages of increased cost of working and diminished value of produce, he proceeded to say that, "assuming 4,000 ft. as the greatest depth at which it will ever be possible to carry on mining operations, and rejecting all seams of less than 2 ft. in thickness, the entire quantity of available coal existing in these islands has been calculated to amount to 80,000 millions of tons, which, at the present rate of consumption, would be exhausted in 930 years, but with a continued yearly increase of 2,750,000 tons, would only last 212 years. It is clear that long before complete exhaustion takes place, England will have ceased to be a coal-producing country on an extensive scale. Other nations, and especially the United States, which possess coal fields thirty-seven times more extensive than ours, will then be working more accessible beds at a smaller cost, and will be able to displace English coal from every market."

Never before had the important problem of the exhaustion of England's coal supply been so lucidly and logically put, and never before had it induced such a large amount of public interest. For a number of years, indeed, it became the question of questions in the scientific world, and in 1866 a Commission was appointed by the House of Commons to inquire into the probable extent and duration of our coal supplies. Of that Commission Sir William G. Armstrong was appointed a member, while he was, at the same time, one of the most valuable witnesses on the several matters which the Commission was required to investigate. Holding that the general subject of the waste of fuel in combustion might properly be considered under three heads—consumption of coal for household purposes, consumption of coal for motive power, and consumption of coal for manufacturing purposes—he pointed out that in each of these divisions the waste was excessive but remediable. The manner in which coal was applied for culinary and domestic purposes he held to be very extravagant. It was quite practicable to have a perfectly agreeable heat with a fraction of the quantity of fuel now used; and he pointed out that the proper mode of heating air was to bring it into actual contact with the heated surface. From an engineering point of view, some of Sir William's evidence was rather remarkable. He thought that eventually the principle of the caloric air-engine with the regenerator would supersede the steam-engine. He believed that three times as much coal was used in raising motive power as would be necessary with the best steam-engines; and pointed out that great economy of fuel could be effected by introducing expansive engines, by



GEMS OF INDUSTRIAL ART.—PORTION OF THE SURTOUT OF THE HOTEL DE VILLE, PARIS.—By Christofle and Co.

using steam at a high pressure, and by increasing the heating surface of the boilers.

In the session of 1872-3 Sir William Armstrong was elected president of the North of England Institute of Mining and Mechanical Engineers, and in his presidential address he again called attention to the consumption of coal, although to a different aspect of the question. He stated that if the then consumption of coal in the United Kingdom was taken at 110 million tons, exclusive of exportation, and if they assumed the additional cost to the consumers to be 8*s.* per ton over all, the annual loss to the community from the additional value of coal during 1872-3 amounted to no less than £44,000,000 sterling! He added, "had a Government tax of £44,000,000 been levied upon coal, in addition to existing taxation, the effect would have been regarded as utterly ruinous, not only in regard to its prodigious amount, but also on account of its repressive effect on every kind of production. Yet we are now paying the equivalent of such a tax, with this difference, that the money does not go into the coffers of the nation. For many years our consumption of coal has been increasing at the rate of four per cent. per annum, computed at the rate of compound interest, and if the consumption of coal continued to advance at this rate, we should in eighteen years double our consumption, and in thirty-six years it would be quadrupled." Our readers will remember that no explanation respecting the coal famine, nor any record of its results, had a more weighty influence with the general public than these eminently practical and suggestive conclusions.

Before the "Select Committee on Letters Patent," appointed in 1870 to deal with the question of the patent laws, Sir William was examined as a witness. His opinion he declared to be adverse to the patent laws, not because he thought the authors of valuable inventions should go unrewarded, but because, in the great majority of cases, a successful inventor made for himself a position, which, in its pecuniary consequences, carried a sufficient reward; and because the State could well afford to be liberal in special cases of hardship, in consideration of the vast saving that would accrue to the public, if relieved from the burdens of the existing system. He declared his personal experience to be that he had been continually deterred from following up lines of invention, because of the existence of dormant patents; and stated that on one particular occasion he had proceeded with a mechanical invention of considerable promise, when a patentee made his appearance, and demanded a license. "For the sake of avoiding litigation," says Sir William, "I agreed to pay him a licence on a particular thing embodied in my machine, which he had patented, and proceeded further with my invention; but in a very little time a second patentee made his appearance, and said that he was the true patentee, and that the other man had no claim. I was then in the position of having to decide which of the two claimants was the true one. Being quite unable to do that, and being thoroughly annoyed with the whole proceeding, I gave up the investigation entirely, and there was an end of it." Another interesting experience was related by Sir William to the Patent Laws Committee. "It was," he said, "the case of wrought-iron wheels for railway purposes. The Great Northern Railway Company offered to give contracts to those persons who would furnish the best designs for wrought-iron wheels for railway carriages. Several persons gave their minds to it, amongst others myself; and my wheel was one of those that were chosen." In utter ignorance of there being any patent of this kind of wheel, Sir William proceeded to make a large number of them at Elswick, when, "after we had made them, a patentee makes his appearance, and produces a patent more than thirteen years old. and close on expiring, in which some particular element in combination with this patent was defined. The result was that we had to pay 5 per cent. on the value of the wheel in satisfaction of that patent." Some thousands of pounds were thus earned, not by the original patentee, but by some one who had bought up the patent on speculation, and who had no legitimate claim whatever to any reward.

In his recreations and leisure, as well as in his business pursuits, Sir William displays the same unquenchable ardour for scientific pursuits. His grounds, near Newcastle-on-Tyne, are distinguished for the possession of rare plants, flowers, and shrubs that furnish a perennial source of interest and pleasure for visitors of all ranks, to whom they are most freely opened. The grounds of Cragside, near Rothbury, Sir William's favourite residence, are once a week thrown open to the public; and many thousands from Newcastle, Morpeth, and elsewhere, avail themselves of the privilege thus conceded—a privilege, the value of which a virtuoso can alone adequately estimate.

Sir William is a D. C. L. of Oxford, and an LL. D. of Cambridge, and has been honoured besides by orders of knighthood from half-a-dozen foreign Governments.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

IMPROVEMENTS in Sulphuric Acid Making.—BERNADAC patents the use of peculiar arrangements for the production of the maximum quantity of acid possible in a given time; the draught is increased by a steam-jet in the chimney, and series of towers are used instead of chambers; the first of these has a dome into which a pipe injects sulphurous acid, together with air and nitric acid; steam is passed in by a lateral tube, which also serves to introduce acid charged with nitrous fumes; this falls on to a perforated cone. The gases pass down through the tower, traversing a series of shelves, carrying perforated capsules so as to bring about an intimate mixture. After passing through the first tower the gases ascend up a second passing through similar shelves; they then circulate through numerous spiral helices alternating with perforated plates; in this tower the chief portion of the acid is formed; finally, the nitrous gases are absorbed in a third column with alternate stages, into which strong sulphuric acid is admitted. Instead of these towers, chambers filled with lumps of coke, glass, &c., may be used. *Bulletin Soc. Chim. Paris, xxi.* 526.

[*Note by Abstractor.*—It seems *a priori* very questionable if any gain in time in this arrangement can counterbalance the extra first cost of such complex apparatus, and the enormous wear and tear which must be occasioned.]

Sulphuric Acid.—E. KOPP reports on this subject in connection with the Industrial Exhibition at Vienna. The production of sulphuric acid in Germany, has risen during the last year, from 1,130,000 quintals of 50 kilos. each to 1,690,000 quintals; the use of pyrites instead of sulphur is on the increase. Improved roasters for pyrites "smalls" have been proposed, notably by Perret and Gerstenhœffer; in these the smalls are continually brought down from a higher stage to a lower level, being spread in thin layers on horizontal plates, a current of air ascending over them; a portion of the heat generated by the combustion of the sulphur is used to maintain the temperature, the escaping hot gases being made to pass beneath the lowest stage and thus to heat it: the roasting is thus rendered so perfect that the burnt cinders contain no more than 1 per cent. of sulphur.

HASENCLEVER and HELBIG have constructed a continuous pyrites roaster wherein the powder or small lumps is made to pass over a series of zigzags in a burner heated by the hot gases from a lump pyrites kiln close by. Economy in labour is thus produced, but the roasting is slow and less complete than in Perret's furnace. The same inventors have constructed a furnace for utilising sulphur from *blendes;* this consists of a roaster and a kind of muffle the sole of which is inclined at an angle of 42°; the blende is roasted by means of combustibles, the gases from which pass through the roaster and surround the muffle passing beneath its sole to the chimney: the ore slides gradually down the inclined surface in a thin layer. 80 per cent. of the sulphur present can thus be utilized.

For concentrating the acid VAN HEMPTINE proposes to evaporate in vacuo in leaden vessels, rendered capable of resisting pressure by being filled up with stones: others employ leaden vessels heated by a flame playing over the surface, or by a steam worm at 3 atmospheres (135°), or by injecting hot air at 150°. The heat from the pyrites kilns may also be utilized for concentrating acid already at 50.° Glover's towers consist of compartments or towers of lead 7·5 meters high, 0·24 meters square, lined internally with refractory bricks not affected by acids, and filled with lumps of brick below and pieces of quartz and coke above, the whole resting on a perforated arched vault. Three apertures exist in the upper part of the tower; two for the introduction of chamber acid and acid at 60° containing nitrous fumes from the Gay-Lussac's tower; the third for the removal of the vapours and gases evolved to the chambers. Two apertures also exist at the base of the tower below the arch; one for the entrance of hot sulphurous fumes, the other for the removal of the concentrated

acid. When the Gay-Lussac's tower acid at 60° and the chamber acid at 50° meet some nitrous fumes are evolved; the last portion is removed by the hot sulphurous gases, which also carry off much water: the concentrated acid that runs out at the bottom is strong enough for making salt cake and for use in the Gay-Lussac's towers. These Glover's towers are however costly to set up, and they require frequent repairs; moreover the hot sulphurous gases carry with them solid particles which render the acid made more impure than ordinary acid when the solid particles mainly deposit in the cooling flues before reaching the chambers.

MATHEY & Co. and also DESMONTIS exhibit platinum concentration stills of improved form, with deep capitals to allow of the more complete condensation of weak acid volatilized; a peculiar syphon arrangement is also shown.

The author also describes the process of DUNLOP, W. HOFFMANN, and WELDON for the recovery of manganese; the first consisting in the precipitation of carbonate of manganese by chalk and its subsequent calcination in a dry state at a temperature of 300° to 400°; the second in the production of manganese sulphide by means of vat waste, and the roasting of this so as to form sulphurous acid, and a mixture of manganese sesquioxide and manganese sulphate, which is heated with nitre, whereby nitrous fumes are disengaged and manganese oxides and sulphate of soda formed; and the third is the oxidation of manganous hydrate by air in the moist way in presence of lime.

H. KUHLMAN finds that nitrous vapours convert manganous hydrate into nitrate without any evolution of nitrogen or nitrous oxide; nitric oxide is formed, however, and is converted into hyponitrous acid by the oxygen of the air; the nitrate of manganese when heated to 200° forms manganese dioxide and nitrous vapours, which latter can be used to convert a fresh portion of manganous hydrate into nitrate.

The author describes rotating furnaces and Siemen's furnace for alkali-making, and various improvements introduced in the caustic soda manufacture, such as the use of air instead of nitre for oxidizing sulphides, and that of sulphate of lead, whereby sulphides of iron and lead are thrown down and sulphate of sodium formed, the double sulphate of sodium and iron present in the ley being decomposed. The processes of Kopp, W. Hoffmann and Briquet, of Mond, of Shaffner and d'Aussig, for the recovery of sulphur are also described; the first consists in the use of vat waste to form manganese sulphide as above stated; the second in oxidizing the moist waste by a current of air, lixiviating with water, and treating the solution of mixed sulphur compounds with hydrochloric acid, whereby sulphur is thrown down; and the third depending on much the same principles, a long exposure to air being employed; the crude sulphur is purified by heating along with a little vat waste in a closed boiler with steam at three or four atmospheres; hydrochloric acid is thus saturated, and sulphide of arsenic dissolved out by the sulphide of calcium formed; the sulphur is melted and can be forced out and cast into sticks, &c.

The manufacture of superphosphates is referred to and statistics given as to the production of potash at Stassfurth, Leopoldshall and Kalusz (Eastern Galicia) where similar deposits occur, mainly of *sylvine* (potassium chloride) and *Kainite* (potassium sulphate, magnesium sulphate, and magnesium chloride).

It is stated that to prepare 100 kilogs. of soda by the carbonate of ammonia process there are required

250	kilogs.	of coal,
50	„	coke,
200	„	salt,
100	„	limestone,
10	„	sulphuric acid at 50° to condense the ammonia.
2 to 3	„	sulphate of ammonia lost.

The cost of working, 4 francs, and 1¼ francs for general costs, must be added to this estimate. *Bulletin Soc. Chim. Paris, xxi.* 428, *from the Moniteur Scientifique.*

Boric Acid.—GUTZKOW extracts boric acid from boronitrocalcite and analogous minerals by heating the powdered substances with sulphuric acid in leaden vessels until a thick magma is formed, which hardens on cooling; the masses are then heated to redness in cast iron cylinders, through which steam is blown; the boric acid is then driven off along with the steam and condensed in leaden chests; sulphuric acid may be removed by placing a layer of coke in the top of the cylinder; the sulphuric acid is thus converted into sulphurous acid, which escapes.

Boronitrocalcite is met with at Churchill, Esmeralda and other places in Nevada (North America); it contains

Boric acid	42	per cent.
Soda	8	„
Lime	13	„
Water	37	„
	100	

Bulletin Soc. Chim. Paris, xxi. 471, *from Chemisches Centralblatt, v.* 66.

The Ammonia Process for Manufacturing Soda from Common Salt.—A. BAUER finds that the decomposition of chloride of sodium is never complete, the loss of salt being about one-third of the quantity used; when bicarbonate of sodium is brought into contact with chloride of ammonium there is always more or less carbonate of ammonium produced whilst chloride of sodium is reproduced; the same result takes place with carbonate of sodium. *Berichte der Deut. Chem. Ges.* 1874, No. 4.

Valuation of Cinchona Barks.—PERRET exhausts 10 grammes of bark with 50 of alcohol at 90 per cent. mixed with 5 grammes of very caustic alkaline silicate solution, at 40° B. After ten minutes boiling the whole is filtered, and again treated with 30 grammes of alcohol, and 2·5 of silicate, and finally with 20 grammes of alcohol. The filtered extract is evaporated to a honey-like consistency, and treated first with 30, then with 20, and lastly, with 10 grammes of ether at 65°; the ethereal solution evaporated to dryness leaves quinine, which is dissolved out by dilute sulphuric acid, and precipitated either in the free state or as oxalate; the whole operation only lasts three hours, and yields quinine not containing more than traces of quinidine and cinchonine. *Bull. Soc. Chim. Paris, xxi.* 433.

Soap for Cleansing Textile Fabrics.—DECURTY patents the following composition:—

Water	1,000 litres.
Olive oil or oleine soap	0·52 kilogs.
Soda	2·11 „
Lime water	0·71 litres.
Cheese flour	0·05 kilogs.

Bulletin Soc. Chim. Paris, xxi. 380.

Utilization of Soap Liquors and Alkaline Liquors from the Cleansing of Greasy Substances, &c.—H. VOHL states that such liquor may be divided into three classes, viz. waters from the removal of suint, &c. from wool, from wash houses, &c.; soapy liquors from silk cleansing, which contain much grease, gelatine, and similar substances; and fatty matters from Turkey red dyeing. Liquors of the first class chiefly contain the potash and soaps of linseed, colza, and fish oil, fatty acids with more or less of resins and miscellaneous impurities; only soaps of very low quality can be made from the fatty matter thus regained; those of the second and third classes, however, yield a clear limpid, and nearly colourless and inodorous oil, which produces good soaps; the liquors from the "brightening" of Turkey red, however, are only suitable from soft soaps. From all of these fatty substances good illuminating gas is obtainable by suitable destructive distillation.

The direct treatment of bulky liquors by mineral acids is inconvenient for several reasons; the author proposes the production of lime, or better of magnesia, soaps in the factories where the liquors are produced; these earthy soaps can be readily collected and transported to other establishments, where the fatty matters are regained, so that the fat-recovery processes need not be carried out on the spot. Magnesia soaps do not occupy so much space, being relatively more compact; *i.e.* a magnesia soap contains 60 per cent. of fatty matter, whilst a calcareous soap only contains 40 per cent. These earthy soaps may be used to great advantage in the production of illuminating gas. *Bull. Soc. Chim. Paris, xxi.* 478, *from Chemisches Centralb. v.* 62.

§ 2. *Metallurgy.*

Restoration of Burnt Steel.—J. L. DAVIES gives the following simple and efficacious plan of restoring to steel which has once been burnt its usual valuable qualities, by the use of a fluid which leaves scarcely anything to be desired on the score of cheapness and utility.

Chisels, &c., which have been burnt and rendered useless may be restored as follows:—the burnt steel must be heated red hot, then plunged into the "restitutor" for a few seconds; then reheated and cooled in the ordinary way. The steel after this process is perfectly restored.

The fluid is simply resin oil mixed with about a fourth of its weight of the residue of paraffin stills. *Iron, May* 30, 1874, p. 677.

Regeneration of Steel.—Several swords, valued not only for their workmanship and temper, but for the circumstances under which the owner had become possessed of them, had been reduced by a fire to the condition apparently of twisted pieces of hoop iron. They were sent to Birmingham, and some time afterwards returned in a condition "differing but little from what they had been before their fiery ordeal." The swords had been hung upon the walls, and afterwards, when disinterred from the ruins, were "mere crumpled bits of burnt and rusty iron." Messrs. WILKINSON say that it is often of great importance that the outer scale left by the fire should not be removed, nor any attempt at cleaning the surface be made unless by experienced hands. In the case of sword blades especially, they find that the minutest details of embossed ornament can generally be traced over the outer scale of burnt steel, and may be copied and restored unless obliterated by friction. Inlaid or damascened gold work on steel will stand a very high degree of heat without being destroyed, and the figure of the genuine Damascus blades, being a part of the structure of the metal, can be restored as long as any of the steel remains. *Iron, May 30th*, 1874, *p.* 677.

Mechanical Puddling.—DANKS patents a mechanical detail, as an improvement on his now well-known rotary puddling and heating furnaces, by way of obviating all possibility of the water, used to keep the cylinder ends and the facing or abrasion rings from overheating, finding its way into the cylinder: for this object the joint is protected by a flange or gutter, on the inner periphery of the abrasion rings, extending across the joint between them and the cylinder-plate.

R. SMITH CASSON patents an improvement consisting chiefly in the application of a movable bed to a part of the furnace, and of a method of movable fire-bars to the combustion chamber.

The furnace consists of three compartments; the fire or combustion chamber, the heating or preparing chamber, and the puddling chamber; in the first-named the fire-bars are so constructed and arranged as that they may be moved alternately, and at the front and rear ends in turn, whereby the accumulation of clinkers on the bars is prevented; in the second-named compartment, where the iron or steel is heated or prepared previous to its introduction for manipulation into the last-named or puddling chamber, the bed or floor is constructed so as to be movable, and is thus raised and lowered, and inclined by suitable mechanism, the lowest part being turned to the aperture of communication with the puddling chamber; thus the iron or steel when heated may be readily transferred from the preparatory to the puddling chamber, or, if fused, the molten metal is caused to flow from the one to the other. For the convenience and protection of the puddler an arrangement of sheet iron screens, supported close to and parallel with the front wall of the furnace, and kept cool by currents of air caused to ascend between the wall and the screens; is employed to ward off the excessive heat. *Iron, May 30th*, 1874.

Compound Cupola Furnace.—SWAIN proposes the use of a cupola furnace, in which an auxiliary reservoir is attached to the bottom of the cupola. The metal as it liquefies, instead of lying, as heretofore, in the hearth of the cupola, below the tuyères, is in this arrangement tapped off and collected by a passage in an auxiliary chamber or hearth. In the former case the metal is tapped off just as impure as it falls through the mass of coke, ore, and sulphurous gases, in the charge above. In the latter arrangement, when a damper is opened, a portion of the hot air from the tuyères, having passed across the hearth, finds its way into the reservoir and plays over the extended surface of the bath of metal. In this way much of the excess of carbon is oxidized, and the sulphur, silica, and other impurities are oxidized and carried off as gases up an auxiliary chimney.

The advantages of this arrangement are numerous. This reservoir, which can with ease be applied to any old cupolas, enables a much larger quantity of metal, compared with the size of the cupola, to be stored up and kept warm than can be done with the old style of furnace. This gives an easy method by means of which the capacity of any existing cupola may be readily increased to meet a demand for heavier castings. It is also noticeable that the part of the blast producing heat to keep the charge liquid, is not obliged, as in ordinary cases, to pass through the whole of the fuel. Thus a considerable economy is claimed to be effected. The fuel used being simply that required to effect fusion, the fusion being afterwards kept up apart simply by the hot-blast, and the oxidation taking place in the bath itself.

The advantages that the inventor claims are as follows:—(1) the fusion takes place more rapidly, and the weight tapped is much greater than under the old system; (2) the passage of the hot blast over the surface of the liquid metal facilitates the oxidation of all impurities contained in the metal; (3) the liquid metal is heated more strongly, and is better mixed; (4) there is economy of time; (5) large masses can be cast with the same ease as small ones; (6) a considerable economy of fuel is effected; (7) the liquid metal can be retained and kept hot for a considerable time. In fact, the action of the reservoir has all the effect of refining, the silicon, sulphur, and phosphorus being largely carried off in the bath.

The same cupola and reservoir may also be applied for the fusion of pig-iron for puddling. The liquid metal will run then directly from the reservoir to the puddling furnace, and thus save the reheating. This would represent a large economy over the ordinary methods. Another advantage is obtained in the reduction of the expenses in repairs to the puddling furnaces, caused by the reduction of the pig-iron on the hearths of those furnaces. Since if the metal is introduced in a liquid condition into the furnaces, the production of iron is doubled in a given time, the expenses of repairs and interest on capital are all halved.

The idea of puddling direct from a cupola is by no means novel, but it has hitherto been practically unsuccessful by reason of a want of refining in the products of cupolas, and by difficulties which are obviated by the use of an auxiliary reservoir, upon the surface of which a refining jet of hot air plays. The same application might, perhaps, be made to the Bessemer apparatus, which requires costly fusing furnaces. *Iron, June 6th*, 1874.

Chinese and Japanese Bronzes.—H. MORIN has examined several bronzes covered with a dark patina, not caused by the action of sulphur nor by the application of varnish, but due to the presence of a considerable quantity of lead. Thus the following numbers were found:—

Tin	4·36	2·64	5·52
Copper	83·72	82·90	72·09
Lead	9·90	10·46	20·31
Iron	0·55	0·64	1·73
Zinc	1·86	2·74	0·67
Arsenic	traces	0·25	traces.

Another kind of bronze contained a larger proportion of tin and of zinc:—

Tin	7·27	6·02
Copper	72·32	71·46
Lead	14·59	16·34
Iron	0·28	0·25
Zinc	6·00	5·94
Arsenic	traces	traces.

The author attempted to reproduce these bronzes by melting together the ingredients in the following proportions:—

	No. 1.	No. 2.
Tin	5·5	5·0
Copper	72·5	83·0
Lead	20·0	10·0
Iron	1·5	—
Zinc	0·5	2·0
	100·0	100·0

Mixture No. 1 was very fragile. No. 2 produced a bronze very like the Chinese bronze, possessing the same fracture and lustre; when heated in a muffle it became covered with a black patina, whereas ordinary modern bronzes scale under these conditions. *Bull. Soc. Chim. Paris, xxi.* 519; *from Comptes Rendus*, 78, 811.

Native Silver.—A. H. CHURCH gives the following analyses of two old specimens of native silver from Allemont (Dauphiné):—

	Foliated.	Ramose.
Silver	71·69	73·39
Mercury	26·15	18·34
Antimony	2·16	8·27
Arsenic	traces	traces
	100·00	100·00
Specific gravity at 16° C.	11·10	10·05

Although crystalline in structure, both specimens were flexible and malleable. *Chemical News, xxix.* 225.

Extraction of Silver.—T. J. BARNARD patents the following improvements in the concentration and treatment of low class and unmerchantable ores and minerals. Throughout the kingdom, and more especially Devon and Cornwall, copper lodes contain an average of 4 to 8 oz. silver per ton of stuff; hitherto this has never been considered sufficient to pay for the cost of extraction. The average quality of copper ores sold to the smelters is about 7 per cent., and repeated washings, dressings, and concentrations are resorted to at the mines, in order to arrive at this, but much is wasted, and copper held in solution finds its way into the rivers. The miner gets no benefit whatever from the silver; 1 to 2 per cent. copper ore is unmerchantable, and is allowed to accumulate in heaps at the mines. The copper ores containing only 1 to 2 per cent. of copper are equally as rich in silver as the higher copper material. From fifty to 100 tons of 2 per cent. copper ore are roasted with common salt and chloridized in the ordinary manner, which converts the silver as well as copper into chloride. The chloride is put into strong wooden tanks, with false bottoms, and boiling brine passed through, which holds the silver as well as the copper in solution. The liquid is then conveyed through a long run of launders containing iron into a large wooden tank, and is kept hot by a jet of steam; and scrap iron or zinc in the tanks as well as in the launders throws down a copper precipitate of about 60 per cent. copper, but containing several hundred ounces of silver to the ton; this is treated by any of the ordinary well-known methods for the extraction of the silver from the copper.

[Probably Claudet's iodide process might be applied directly to the liquors obtained in this way with advantage; *vide* "Practical Magazine," No. 18, p. 433.]

Ashantee Gold.—A. H. CHURCH gives the following analysis of an average sample of gold taken from several nuggets:—

Gold	90·055
Silver	9·940
Copper	very minute trace
Iron	trace
	99·995

Specific gravity at 16°, 17·55.

The colour is uniform and rich, part of the tint being due to the adherence of a trace of red hæmatitic earth adherent to the specimens. *Chemical News*, *xxix.* 199.

The Patera Mercury Furnace.—KUSTEL describes this furnace as being in principle a muffle furnace; it requires the previous pulverization of the ore, but this adds but little to the cost, whilst the yield of mercury is far greater than with the ordinary retort system. At Idria, where the latter process is used, 37 per cent. of the mercury is lost, this estimate being stated to be 12 per cent. too little; the Patera furnace, on the other hand, gives a yield of 84 per cent., the residue being wholly devoid of mercury. It is not requisite that a temperature above a red heat should be employed, a slightly lower temperature sufficing throughout. *Bull. Soc. Chim. Paris*, *xxi.* 472, *from Bau- und Hütten-Zeitung*, *xxxiii.* 91.

Bismuth.—A. VALENCIENNES states that a Bolivian bismuth ore is worked up at St. Denis by the following process.

The ore contains:—

Bismuth	22·8	30·05
Iron	10·2	16·90
Copper	9·5	12·15
Sulphur	19·5	16·90
	100·0	100·00

Traces of antimony, lead, and silver are also found. The ore is roasted in a reverberatory furnace for twenty-four hours, coal dust being thrown in from time to time, and the mass well worked with an iron rabble. The roasted ore is then mixed with 3 per cent. of coal and a flux composed of lime, soda, and fluor spar, and the mixture fused in a reverberatory furnace with a dish-shaped bed; at first the damper is closed so that the reducing flame of the furnace may assist the coal in reducing the oxide present; after two hours the damper is opened, and the temperature raised to whiteness; in two hours more the whole is run off, and separates on cooling into three layers, the lower of metallic bismuth, the middle one of sulphides of copper and bismuth, and the top one of a vitreous scoria.

The crude bismuth thus obtained contains 2 per cent. of lead and antimony, 2 of copper and traces of silver; the antimony is readily separated by means of fusion with nitre; the other metals are removed by the wet process if subnitrate is to be prepared.

The matts contain 5 to 8 per cent. of bismuth, which is partly extracted by a repetition of the process; the mass left from this second operation contains 1 to 2 per cent. of bismuth, which cannot be extracted in the dry way.

Formerly a process was used consisting in heating the ore, fused and deprived of gangue, with iron filings (12 per cent.) and scoriæ (30 per cent.), with a little soda: but the sulphide of iron formed attacked the furnace so energetically that this process was abandoned in favour of the one given above. *Annales de Chimie et de Physique*, [4] *i.* 397. *Bull. Soc. Chim. Paris*, *xxi.* 426.

§ 3. *Dyeing, Calico Printing, Bleaching, Tanning, and allied subjects.*

Aniline Blue for Cotton Warps.—The warps are worked in the following decoction (allowed to stand till clear before use):—

Sumach	2 lbs.
Marseilles soap . . .	¼ „

and allowed to lie therein over night; they are then soaked for six hours in red liquor at 2° B. An aqueous solution of blue (of as green a shade as possible) is prepared and filtered, one-tenth of the spent red liquor bath being added to it. The goods are passed through this vat cold at first, and are then gently heated therein, and finally boiled: lastly, they are rinsed, passed through gum tragacanth, and finished. *Reimann's Färberzeitung*, 1874, *No.* 6.

Impurities and Adulteration of Aniline Violet.—F. SPRINGMÜHL found in one specimen of mauvein Glauber salt to the extent of 5 per cent. The violet most frequently met with in commerce is made up of various proportions of mono and diphenyl rosaniline. Very frequently unchanged magenta and aniline hydrochloride are found in it, and often it contains arsenic, though never to any considerable extent; the maximum quantity found in twenty-eight specimens (eight of which were altogether free from arsenic) was 0·9 per cent. Magenta, aniline, and their hydrochlorides are detected by treating the violet with water, whereby these admixtures are dissolved out. In order to separate magenta, the dye stuff under examination is dissolved in glycerin, and the solution diluted with a large quantity of water, whereby the violet is precipitated, whilst the magenta remains dissolved. The soluble violet, occurring in the market, is always more or less adulterated with Glauber salt; the author detected in a particular instance as much as 20 per cent.! Finely powdered charcoal appeared in some instances, to the extent of 8 per cent. Hoffmann's iodine violet often contains bromine and small quantities of some iron salt; the most usual adulteration is gum, of which as much as 12 per cent. has been found in one sample.—*Chem. Soc. Journal* [2], *xii.* 612, *from Chem. Centralbl.* 1873, 207 *and* 220.

Impurities and Adulterations of Aniline Green.—F. SPRINGMUHL states that aldehyde green usually occurs as a paste, often smelling of aldehyde, sometimes as a liquid or solid mass. The demand for this dye-stuff is now very small. It usually contains a few per cent. of inorganic constituents left on incineration, and more or less matter insoluble in water, valueless as a dye, and often injurious; this usually constitutes a dirty green or almost black powder, very difficult to separate by filtration.

Iodine green differs much in price and purity; nevertheless the price is not always an index of purity, as it is often found that samples alike in price are in practical value in the ratio of one to two. Crystalline iodine green is usually purer than the amorphous variety, but not always. Different specimens vary very much in shade, yellow tinges being given by the addition of picric acid or other yellow dye, blue ones by means of aniline blue (soluble blue). The presence of this latter is best seen by artificial yellow light, especially when only small quantities are present; larger amounts may be detected by the addition of picric acid and glycerin, whereby the picrate of the green dye stuff is precipitated, and a deep blue solution formed. Some samples of the commercial green consist of the picrate of the green base mixed with more or less blue to counteract the yellow cast; in this case it is only necessary to add water, which dissolves the blue and not the picrate. Picric acid may be detected by boiling for some time with potash, and treating the potassium picrate formed with potassium cyanide, so as to produce isopurpuric acid.

Iodine green contains a variable amount of iodine, often mixed with bromine and chlorine, the latter coming from sodium chloride, used as a precipitant, the former from the use of methyl bromide, in place of iodide, in the preparation of the dye-stuff (dimethyl iodide or bromide of trimethyl rosaniline).

Sodium acetate and insoluble, almost black substances are often present, also some aniline violet. These are impurities accidentally introduced by the mode of manufacture. Intentional adulteration is comparatively rare, sugar being the usual adulterant. Quantities of this substance, as high as 18 per cent. of the air-dry mass, have been detected. Lead, apparently as picrate, has also been found, also common salt, magnesia, and oxide of chromium; Schweinfurth green, though not an improbable adulterant, has not been detected by the author, although arsenic has been found in certain samples.—*Chem. Soc. Journal* [2], *xii.* 611, *from Chem. Centralbl.* 1873, 140.

Aniline Grey for Calico Printing.—E. LAUBER obtains a fine grey by careful oxidation of aniline on the fabric. The following solution is made:—

Water	3¾ litres.
Chlorate of potassium	625 grammes.

And to it is added (after cooling),

Gum-water	6·5 to 1 kilogramme.
Salammoniac	312·5 grammes.
Tartrate of chromium and potassium	1500 grammes at 30° B.
Aniline	200 „
Tartaric acid	1160 „

To prepare the tartrate of chromium and potassium, 960 grammes of potassium dichromate are dissolved in 3 litres of hot water; after cooling to 44°, 1140 grammes of powdered tartaric acid are added gradually, all elevation of temperature that might alter the product being avoided; the chromic compound may also be previously reduced by some cheaper reducing agent, such as alcohol, sugar, &c. After printing with the above mixture, the goods are aired in a warm room at 32° for forty-eight hours, and then well washed in a stream for an hour.

By the use of a larger quantity of gum-water the shade may be rendered lighter; a very pure grey is thus obtained, which will bear all the operations required for alizarin red, save only treatment with tin-salts. *Bulletin Soc. Chim. Paris, xxi.* 523, *from Musterzeitung*, 1874, *No.* 1.

Madder.—VERSMANN states that the madder plant has been cultivated in Holland for more than three hundred years; France (especially the neighbourhood of Avignon) now produces about one-half of all the madder consumed, to the value of about £750,000 per annum. Turkey and South Russia also supply considerable quantities of high quality. Some experiments in cultivating madder in this country have been made in Derbyshire some years ago, but with indifferent results. The soil, the climate, and the weather have the most decided influence upon the growth of the plant, and the subsequent development of the colouring principle. The Dutch madder will dye red, but not purple, and the colour is not fast. Naples madder dyes good red and purple, but the colours are not fast; that of Turkey dyes good red and purple, and is very fast. France supplies the market with two qualities, called "rosées," from their dyeing beautiful reds and pinks, and "paluds," which give a good purple, besides a fine red; this is the best French quality. The last name is derived from the fact that the plants are grown on marshy land.

The cultivation of the plant and the ultimate separation of the colouring principles is a matter of much time and uncertainty. The root must remain in the ground for a long time,—in France two or three years, in Turkey five and seven years,—and after having been dried and coarsely powdered, it must be kept another year or two to develop the colouring principles which are not ready formed in the root.

For many centuries, and until the beginning of the present one, the root was used direct, and no attempt was made to separate the colouring matters, or to apply them in a concentrated and pure form; but with the development of technical industry and scientific investigation, the concentration or separation of the valuable constituents gradually commenced. The first step is the manufacture of "fleur de garance," madder deprived of all substances soluble in water, and then dried again, which reduced the bulk to about 60 per cent. The washings contain a considerable amount of sugar, which by some French manufacturers is converted into alcohol. A ton of madder gives about 15 gallons of alcohol, of rather unpleasant flavour, but well adapted for technical purposes.

Garancine is madder further treated with sulphuric acid, which destroys part of the ligneous fibre, yielding about 25 per cent., in the form of a fine powder of light brown colour.

Alizarine verte and purpurine are the results of treating madder with sulphurous acid, which dissolves both; after adding sulphuric acid to the solution, and heating to 40° C., purpurine separates (about half or three-quarters per cent.), and, on further heating to 100° C., alizarine verte separates (about 3 per cent.)

Yellow alizarine is obtained by further purifying this alizarine verte.

Extracts of madder are mostly obtained by treating the root with boiling water, collecting the precipitates which separate on cooling, mixing them with gum or starch, and adding acetate of alumina or iron. This is, in fact, a mixture of colouring matter and a mordant, which may be used for printing direct. *Paper read before the Society of Arts.*

New Naphthaline Dye.—M. BALLO has obtained a blue dye stuff, by the action of the air on the product of the action of naphthylamine on brominated naphthalene; it forms a substance soluble in alcohol, with a fine violet blue tint, and is the hydrobromide of a base precipitable in dark blue flakes by ammonia. *Bulletin Soc. Chim. Paris, xxi.* 520. *From Dingler's Pol. Journal, ccxi.* 301.

Cresylol Yellow.—H. WICHELHAUS states that this substance is the potassium salt of dinitrocresylol, which is represented by the formula, $C_6 H_2 (NO_2)_2 (CH_3) (OH)$. Golden yellow (*jaune d'or*) appears to be identical with this body, whereas Victoria yellow (jaune Victoria) is a different substance, isomeric with the jaune d'or. Thus—

	Melting point.	Solubility at 16° in 100 parts of water.	Tint.	Water of crystallization.	Colour of silver salt.
Jaune d'or	82	1·43	Red.	Nil.	Red.
Victoria yellow	109-110	3·12	Yellow.	½ H_2O	Orange yellow.

The tinctorial power of each of these dye-stuffs is not very great. *Bulletin Soc. Chim. Paris, xxi.* 522, *from Berichte der Deut. Chem. Ges. vii.* 176.

Brilliant Green for Wool and Mixed Goods.—A mixture of aniline blue and picric acid dyes wool a bright green. For every 25 kilogs. of wool, 250 grammes of Nicholson blue, and 1 kilog. of borax are used; after two hours a portion of this wool is soured with sulphuric acid; when the required shade is developed the goods are drained (not rinsed) and then placed in a bath containing 150 grammes of picric acid and 750 of sulphuric acid; when the green is developed to the required shade the goods are rinsed. For certain kinds of goods a bottom of yellow wood or quercitron mixed with an equal quantity of sumach may be given; the blue bath (with somewhat less borax) is then used, soap being also added, and finally the tint is brightened in a decoction of terra-merita mixed with indigo carmine and sulphuric acid. The following quantities may be used for 25 kilogs. of wool:

Yellow wood	4 kilogs.
Sumach	4 „

After boiling for an hour the goods are allowed to cool in the bath and are then dyed at 50°—75° in a bath of

Nicholson blue	200 grammes
Borax	500 „
Soap	500 „

The brightening is performed at 50°—60° in a bath of

Terra-merita	1 kilog.
Indigo carmine	100 grammes
Sulphuric acid	500 „

The goods are rinsed in one water only. *Bull. Soc. Chem. Paris, xxi.* 521, *from Moniteur de la Teinture*, 1874. 19.

Chestnut on Silk.—For 10 kilogs. of silk a bath of 10 kilogs of cachou is used, the goods being finally boiled for five minutes; the tint is then fixed by rapidly passing through 200 grammes of potassium dichromate, the bath being at 30°; after rinsing, the tint is brightened by the following bath:

Yellow wood	1 kilog.
Orseille	200 grammes
Indigo carmine	100 „
Alum	500 „
Sulphuric acid	100 „

The proportions may be varied according to the shade required: finally the goods are rinsed once. *Bull. Soc. Chem. Paris, xxi.* 552, *from Moniteur de la Teinture*, 1874. 20.

Chrome Mordant for Calicoes.—The following mixture is made in the open air in a stoneware vessel holding 30 litres.

Chromate of potassium	3 kilogs.
Boiling water	4·4 litres
Nitric acid at 36° B.	2·6 „
White glycerine at 28° B.	0·72 „
Acetic acid at 7° B.	4·28 „

The first three ingredients are mixed and the latter two added gradually; when the frothing has ceased the whole is boiled until a fine green tint is developed. On standing some hours nitrate of potassium crystallizes out; the crystals are washed with 0·8 litre of water, and the washings added to the rest of the liquor; there are thus obtained 10 litres of mordant liquor at 30° B., consisting of nitrate and acetate of chromium, which does not become turbid by dilution, and which can be readily thickened with gum or starch, having no injurious effect on either.

When used by itself this liquor gives a good *vert Havraneck;* addition of logwood gives a black or a grey; of quercitron, an olive; of berry liquor, orange; of catechu, brown; of artificial alizarin, amaranth; madder extract, claret. *Reimann's Färberzeitung*, 1874. No. 10.

Oil Mordant for Cottons.—The following mixture gives good results:

Olive oil	6 lbs.
Alcohol	8 „
Boiling water	8 „
Sulphuric acid	¼ „

The oil and the alcohol are to be well mixed and then the water stirred in, finally the acid is added gradually, having been previously diluted with some of the water. *Reimann's Färberzeitung*, 1874. No. 7.

Psychological Significance of Colours.—GOZLAN associates all emotions of the soul with different colours; thus, compassion is light blue; resignation, pearl grey; joy, apple green; satisfaction, the colour of coffee and milk, &c. *Chemical News, xxix.* 187, *from the Moniteur de la Teinture.*

[We have heard of rosy-fingered morn, and green-eyed jealousy; also of blue-stockings and black-guards; but are unable to appreciate the evidence on which one colour rather than another is selected as the vehicle for particular emotions.]

Egyptian Blue.—H. DE FONTENAY gives the following analysis of this pigment:—

Silica	70·25
Oxide of copper	16·44
Iron and alumina	2·36
Lime	8·35
Soda	2·83
	100·23

No trace of cobalt being present. By heating together the following mixture a blue frit is obtained very similar to the antique azure:—

White sand	70 parts.
Black oxide of copper	15 „
Chalk	25 „
Dry carbonate of soda	6 „

A nearly constant temperature of about 1,000° must be maintained for some time; a higher temperature causes the colour to change, first to a dirty green and then to a brown. *Comptes Rendus*, 1874, *March* 30.

White-Lead Manufacture.—Messrs. ALEXANDER FERGUSSON & CO. carry on their manufacture as follows, at Maryhill, on the outskirts of Glasgow.

The first process is the melting of the lead in a cauldron, after which it is cast into moulds, put into waggons, and weighed. The lead is then taken into the stack room, the floor of which is covered with spent oak bark to the extent of about two feet. Over this layer of bark is a series of small earthen pots, containing a specific quantity of acetic acid. The lead is laid in the form of sheets over the tops of these pots, and the whole is covered with planks, the process being again and again repeated until the stack is filled to the top. In this condition the metal is allowed to remain for three months, at the end of which time, when taken out, it is found that about sixty per cent. of the lead is corroded into a white powdery substance.

The lead is next taken to another department upstairs, where it is passed through a pair of revolving rollers, by means of which the corroded portion of the metal is separated from the uncorroded blue lead, which undergoes another smelting process along with a fresh supply of metal. The white-lead, after passing through these rollers, falls into a vat in a room immediately beneath, from which it again passes down to the grinding room, where the lead is thoroughly washed, cleansed, and refined. The pigment is then deposited in a large vat, where the water which has accumulated in the course of manufacture is separated from the lead. Finally, after hardening in the cooling tanks, the white-lead is put into a drying stove, where it is allowed to remain for about three weeks, after which it is taken out and packed ready for the market. *Iron, June* 27, 1874.

Treatment of Skins and Leathers.—DE SAINTE-MARIE patents a process for the treatment of skins subjected to tanning or aluming, founded on the use of ammoniacal salts so as to get rid of the fixed alkali in the liquors; the direct use of alum, and the employment of sulphate of ammonia, either alone or combined with sulphate of soda, are strongly recommended. *Bull. Soc. Chim. Paris, xxi.* 382.

Removal of Hair from Skins.—M. ANDERSON attributes the action of charcoal as a depilatory (*vide* "Practical Magazine," July, 1874) to the effect of the oxygen condensed in the pores of the charcoal, whereby the fatty matters of the capillary glands are destroyed. If a skin covered with hair be immersed in a mixture of water and pulverized wood charcoal, all the hair is removed in four or five days. The only inconvenience which attends this use of charcoal is that the skin does not swell, so that the cleansing of the inner surface is rendered somewhat more difficult. This however may be remedied by immersing the skin in weak milk of lime for two or three days. When the temperature is at 15° to 20° the hair-removing effect is brought about in four to five days, but at a temperature of 5° to 10° a longer time, seven to eight days, is required.

The leather made from hides thus treated is much tougher than that made from skins treated by the ordinary lime process; less labour is required, and the work is more healthy; the tanning of such skins also occupies less time, and is better accomplished, on account of the neutralization of the tanning principle through the presence of lime in the pores of the hides treated by the lime process. *Bulletin Soc. Chim. Paris, xxi.* 476, *from Chem. Centralbl., v.* 95.

So-called Vegetable Leather.—STŒMMELEN patents the manufacture of a fabric consisting of india rubber masticated, sulphurized, and coloured in the usual way; this is rolled into sheets, coiled on a drum between two cloths to prevent adherence, and then introduced into an autoclave at a pressure of five atmospheres; this steaming is continued for a time proportionate to the thickness of the sheet. Finally, the sheet is desulphurized by means of a bath of bleaching powder, American potash, and green soap; the product constitutes a supple, elastic, impermeable material, not subject to wearing. A black tint is given by means of lampblack; a white, by zinc oxide, and so on, from 5 to 10 per cent. of colouring matter being added. *Bulletin Soc. Chim. Paris, xxi.* 381.

§ 4. *Food and Sanitary Matters.*

Composition of Preserved Meat.—T. R. OGILVIE gives the results of a large number of analyses and examinations of foreign preserved mutton and of uncooked home mutton, and Liebig's extract of beef, of which the following are a portion:—

Foreign Preserved Mutton.

	Fat.	Lean.	Jelly.
Water	28·15	63·20	88·07
Fat	65·77	6·70	0·83
Alcoholic extract	0·93	3·09	3·60
Aqueous extracts	1·77	3·87	6·88
Soluble fibrinous matters	—	3·22	—
Fibrin (syntonine)	3·38	19·92	0·62
	100·00	100·00	100·00

	Foreign preserved mutton. Average contents of tin.	Uncooked home mutton.	Liebig's extract of meat.
Water	61·48	52·59	17·20
Fat	14·62	28·88	0·14
Alcoholic extract	2·87	2·28	53·04
Aqueous extract	4·05	1·85	29·02
Soluble fibrinous matter	2·32	—	—
Fibrin (syntonine)	14·60	11·18	—
Insoluble albumin	—	—	0·40
Soluble albumin	—	3·22	—
	99·94	100·00	100·00
Nitrogen in extractive matters	0·913	0·536	—
Nitrogen in albumin and fibrin	2·314	1·947	—
Total nitrogen	3·227	2·483	0·05

The soluble mineral matters present in the last three instances were—

	Foreign mutton. Average contents of tin.	Home mutton, uncooked.	Liebig's extract of Meat.
Potash	0·298	0·136	9·78
Soda	0·193	0·065	2·48
Phosphoric acid . . .	0·151	0·056	7·89
Chlorine	0·377	0·046	1·76
Sulphuric acid . . .	—	—	0·26
Insoluble mineral substances	0·543	0·150	0·91
Total	1·562	0·453	23·08

In Liebig's extract the water, fat, gelatine, albumin, and fibrine are all either wholly removed or very much diminished in amount. The peculiar renovating properties of this substance mainly depend on the bodies classed together as "alcoholic extract," and including creatine and other analogous alkaloids, and on the potash salts present. *Chemical News, xxix.* 180.

Decolourization of Syrups, &c. FOURMENTIN patents the use of humus, turf, earth, &c., for the absorption of colouring matters, salts, earthy bases, &c. Filtration through such substances completely removes all colour; thus, 50 grammes of dry turf (employed in a moist state) will decolourize a litre of red wine. The decolourizing power of the turf is enhanced by treatment with hydrochloric acid. When mixed with slacked lime, humus-like matters spontaneously oxidize in the air, forming formiates (?).

To render turf fit for use, it should be reduced to large grains, and allowed to remain twenty-four hours in distilled or river water. After draining for twelve to twenty-four hours, it is fit for use, in the same way as animal charcoal. When saturated with colouring matters, the turf is allowed to ferment in the air; the humus-like matter thus becomes oxidized, and forms soluble compounds with the lime taken up (formiates?). The oxidized substances are treated with hot water for four days, and then with cold water containing one kilogramme of carbonate of soda per hectolitre of material to be revivified; finally they are washed with water and drained. *Bull. Soc. Chim. Paris, xxi.* 383.

Grape Sugar in Beetroot Juice.—G. KRAUSE finds that beets naturally contain a small quantity of grape sugar; in all about 0·1 per cent. is present, but the proportion rises to three or four times this amount in spring, when the plants have been underground throughout the winter. A moist season increases the amount. *Pharmaceutisches Centralblatt, xv.* 33.

Phosphoric Acid for Sugar Refining.—SCHEIBLER states that free phosphoric acid, if judiciously added to the syrups, does not cause inversion, whilst the lime present is readily removed by its means, and also some other impurities capable of being precipitated: the alkalies present are diminished (as regards their injurious action), the acids, at first combined with the lime, going to neutralize the alkalies present; the charcoal, too, is less clogged with the syrups, and less treacle is made.

The phosphoric acid is prepared by lixiviating methodically superphosphate of commerce, and adding sulphuric acid to the concentrated liquor; after straining off from the precipitated gypsum, the liquid is digested with phosphate of barium precipitated from phosphoric acid by barium chloride and ammonia; this removes any sulphuric acid or calcium sulphate present, producing in the latter case an acid calcium phosphate in no way injurious. *Bull. Soc. Chim. Paris, xxi.* 472, *from Dingler's Pol. Journal, ccxi.* 267.

Action of Mineral Acids on Sugar Juice.—E. FELTZ finds that the addition of mineral acids, *e. g.* hydrochloric acid, does not greatly increase the production of uncrystallizable sugar, provided that too much be not added: the stronger acid sets free weaker organic acids from the alkaline salts present in the juice, and the total amount of free acid consequently diminishes during concentration, 60 to 70 per cent. of the organic acids being expelled. The hydrochloric acid being thus converted into neutral chlorides does not act prejudicially on the sugar; thus, in one experiment, 18 hectolitres of molasses at 25° B. were mixed with 16 litres of commercial acid mixed with five to six times its bulk of water, so that the liquid (diluted to 20° B.) contained free acid equal to 2·44 grammes of hydrochloric acid per litre, and glucose 8·5 grammes; after concentration to 46° B. in a Roberts apparatus, the temperature being 68°—75°, the liquor (again diluted to 20° B.) contained free acid equal to 0·71 grammes of hydrochloric acid and 9·9 grammes of glucose per litre; the expelled acid containing only traces of hydrochloric acid. *Bull. Soc. Chim. Paris, xxi.* 474, *from Digelnr's Pol. Journal, ccxi.* 326.

Lead in Potable Waters.—FORDOS finds that when water contains bicarbonate of lime or magnesia in solution it acts on metallic lead, forming firstly oxide, which finally becomes carbonate of lead; a precipitate consisting of the carbonates of lead and calcium or magnesium is thus formed. Hence such water does not contain more than an infinitesimal amount of lead *in solution*, the carbonate being almost insoluble. Sulphate and chloride of sodium, chloride and nitrate of ammonium, and sulphate of lime or magnesia, on the other hand, cause a certain quantity of lead to be dissolved in the water; the oxide first formed reacts on the salt present, forms a portion of lead, sulphate or chloride, &c., and setting free caustic soda, &c., which retains a part of the lead in solution as plumbate. Hence when leaden pipes are kept full of stagnant water for some time, the water becomes impregnated with lead, not only as suspended solid lead compound that can be filtered out, but as soluble substances not capable of being removed by filtration. *Bull. Soc. Chim. Paris, xxi.* 439.

§ 5. *Fuel, Gas, Illumination, &c.*

Coals.—E. W. BINNEY reviews recent microscopical observations on the structure of coals; some observers have found little else than the remains of spores and spore cases, others only scalariform and cellular tissues and a few spores, and others little trace of any structure at all; splint or hard coal, soft caking or cherry coal, and Cannel coal represent these three kinds of results; thirty years ago it was supposed that soft coals were chiefly composed of the remains of large plants, such as *sigillaria, lepidodendron*, &c., whilst caking coals are formed of plants of lesser size and much bark. The Boghead mineral is classified by most as a shale rather than as a coal, because it contains little distinctly organized matter save remains of sigillaria and other common coal plants, and is rich in inorganic matter, 25 to 30 per cent. of ash being usually left on incineration. The author believes that the yellow matter found in the vesicles of this mineral is either paraffin or an allied body giving rise to paraffin when heated; it is not found practicable to dissolve out paraffin from the mineral, however, by the aid of solvents; the more *microspores* are present in coals, according to the author's observations, the more brilliant the flame produced on burning and the closer the resemblance in empyreumatic odour to the Boghead mineral; coals full of *macrospores*, however, only burn and smell like ordinary hard coal, thus showing that these two kinds of spores differ much in their inflammable properties, and that the production of paraffin is favoured by the smaller spore and not by the larger ones. *Paper read before the Manchester Lit. and Phil. Soc. Chem. News, xxix.* 183.

Loss of weight in Coal by exposure to air.—VARRENTRASS has made some experiments on the effects of exposure to the air on coal, which show that the loss in weight sometimes amounts to one-third, and that the loss of power is much greater even than that. The loss of weight is due to the slow combustion of the volatile parts of the coal, of which the proportion gradually diminishes in comparison with that of the carbon, ashes, and sulphur. In some of the experiments it was found that after a certain time samples of coal yielded 45 per cent. less than when fresh from the pit's mouth, and had lost 47 per cent. in calorific power. Other samples of the same coal, kept for the same space of time in a closed warehouse, produced only 25 per cent. of gas less, and lost but 10 per cent. of its calorific power. Anthracite was found to suffer from exposure to the air less than common coal, and the bituminous kinds of coal more than others. *Iron, June 6th,* 1874.

Irish Peat.—The Irish Peat Fuel Company report that the manufacture has been prosecuted under most unfavourable circumstances during the winter months in order to test the difficulties in that season of the year; but the results have been satisfactory, for the company has succeeded in obtaining, by a mixture of the lighter and heavier portions of the peat, a fuel having a density within about 15 per cent. of that of coal. This peat fuel is also full of gas, burns with a bright hot flame, and produces a hard cinder, which remains red throughout until it is entirely consumed. The engine and boiler, together with the greater portion of the machinery, are fitted up; and when the mechanical arrangements are all completed, the company will be capable of producing 200 tons of dry fuel per week. The density of the fuel, it is thought, will probably be found to render it suitable for smelting purposes; and, if so, it would be possible to produce a superior quality of iron from some of the Irish ores, which are at present comparatively valueless, owing to the want of a suitable fuel to smelt them. *Iron, May 30th,* 1874, p. 684.

Aniline in Coal Tar.—WATSON SMITH finds that aniline is obtainable from most of the various oils or fractions obtained by the tar distiller during the first rough distillation of coal tar. *Red* or *anthracene oils* contain but little, though sufficient for easy detection; *naphtha*, a much more perceptible amount, especially the heavier naphthas, or the oils known as *light coal tar oils* (sp. gr. 0·9 to 1·0); *benzol* also contains some. The aniline is readily separated from the sulphuric acid used in the commercial purification of benzol and naphtha by addition of excess of soda and distillation, when the aniline comes over together with water; on addition of common salt to the distillate the aniline floats up to the top of the brine in which it is insoluble. The purest aniline and the largest yield is obtained from the heaviest naphtha; from this magenta can be prepared little inferior in tint to that made from ordinary pure aniline oils; from benzol a substance is obtainable containing comparatively little aniline, other analogous substances constituting the main portions. *Paper read before the Chemical Society.*

Artificial Fuel.—LOISEAU prepares a mixture of

Clay	5 parts
Coal-dust	95 „

and moistens it with milk of lime; the product is then moulded into oval lumps which are dried and covered with a film of an impervious varnish made by dissolving resin in crude benzine. A staff of fourteen men can readily prepare 150 tons a day. *Journal of the Franklin Institute, Feb.*, 1874.

Silber's Improved Argand and Batswing Gas Burners.—W. VALENTIN reports on these improvements as follows:—

Argand gas burners, like the burners of the same kind used in oil lamps, have hitherto been limited as to size or diameter of flame, and a consumption of from 5 to 10 cubic feet of gas per hour has for the most part been considered the limit of their performance.

The improvements effected by Silber in Argand burners, consist in various mechanical contrivances for the adjustment of the supply of air to the inner and outer parts of the flame, whereby any size of burner is rendered possible.

Principal among these improvements, there is an inner narrow straight tube open at top and bottom, which, when of the proper diameter, regulates the inner air draughts, and directs a gentle current to the lower parts of the flame which more particularly require it, whilst at the same time a comparatively cold current of air is directed through the central part of the burner, cooling the heated products of combustion as they ascend through the chimney, and causing a gentle influx of fresh atmospheric oxygen into the upper part of the flame. A delicate and well-studied adjustment of the supply of air to the different parts of the flame gives rise to a denser flame and to a more uniformly *white light throughout*, than any hitherto produced by Argand burners, not detracted from, as is usual in ordinary Argand burners, by a portion of *blue* (waste) flame in the lower parts of the zone of combustion.

Not less striking than the remarkable white light which the new burners produce, is the *steadiness of the flame*, so beneficial to the eyes—a steadiness never obtained hitherto by any gas burner. If any proof were wanted that the air supplies are regulated with the utmost nicety, it is found in this and in the fact that common gas can be burnt in these burners with as white, though less dense, a light as the best Cannel gas, the difference being only in the quantities consumed. It also explodes the notion frequently advanced, that the greatest illuminating power is produced by a *yellow* flame, just falling short of the smoking point.

The results of a large number of experiments prove that the greatest amount of light is produced by so adjusting the supply of air to the gas flame as to produce a white and not a yellow light, also that more air rapidly destroys the illuminating power.

Most of the improvements which have of late been made in gas burners, both Argand and flat flame burners, may be ascribed to a reduction to a minimum, at the point of issue, of the pressure under which the gas is consumed; this idea is strictly acted upon in both kinds of Silber burners. The additional improvements consist in throwing no more air into the flame of the new Argand burners than is required to produce the most advantageous combustion, and in properly directing the air into parts of the flame which have hitherto either not received a sufficient air supply, viz., the upper part, or too much air, viz., the lower portions of the flame.

The in-draughts of air in an Argand burner are primarily regulated by the construction of the burner itself and by the height of the glass chimney. The quantity of gas which can be burnt may be said to be in an inverse ratio to the quality, taking the pressure to be the same *i.e.*, if more gas, or a gas of a richer quality were sent through the burners than that for which they are constructed, the flame would come out at the top of the chimney and would smoke; if less gas, the flame would show a somewhat decreased illuminating power, although the whiteness of the flame would be increased. A turn of the gas tap is all that is necessary to adjust the flame.

This general applicability of the new Argand burners is also strikingly illustrated by the fact that cannel as well as common coal gas can be burnt in them to the same advantage. If the richer cannel has to be burnt, the consumption has merely to be reduced, say from 5 cubic feet to about 3·5 or 3·8 cubic feet; or, in order to burn the same quantity of the richer gas, a higher chimney need only be substituted, and, *vice versa*, for a poorer gas a somewhat lower chimney.

From the results of numerous photometrical testings extending over a number of days and conducted under varying conditions, and with different qualities of gas, possessing an illuminating power of from fourteen to seventeen candles for common gas, and twenty-one to twenty-two for cannel gas, when tested according to the methods and with the best test burners now in use in London, it results that the new Argand gas burners, made of porcelain or of metal with steatite tops, with twenty-four, thirty-two, or forty holes, give an average illuminating power of from twenty to twenty-two candles for 5 cubic feet of common City gas when used with a cone, and from eighteen to twenty candles when used without a cone. Cannel gas, producing by the ordinary test burners twenty-one to twenty-two candle light for every 5 cubic feet of gas consumed, gives the same amount of light for about 3·5 to 3·8 cubic feet of gas consumed in the new Argand gas burners.

Besides the great illuminating power of these burners, the following advantages are possessed by them:—

1st. *The burners keep perfectly cool*, although more metal enters into their construction than is probably the case in other burners; the conducting power of the metal for heat is entirely neutralized by the cold air which passes over the metallic surface.

2nd. *The chimney is kept cool in its lower parts* and can be taken off with the hand with the greatest ease at any time.

3rd. *The chimney keeps perfectly clean*, even after having been in use for many days.

4th. The chimney is of the simplest construction and of the cheapest make.

5th. Its height (6½ to 7 inches) is such that a variation in the gas pressure does not materially disturb the combustion; the burners may, in fact, be said to have a range of fully 1 cubic foot, *i.e.*, a burner constructed to burn 5 cubic feet of gas will burn just as well 4½ or 5½ cubic feet of gas.

6th. The burners, when used in chandeliers with opaque white glass globes, produce a most luxurious steady soft light, which, when once enjoyed for some time, will not readily be exchanged again by anybody for the unsteady light of flat burners.

7th. The flame is perfectly steady, no flickering or dancing, so injurious to the eyes, with the least air draught.

Photometrical experiments, conducted in the open air of the testing room, give better results with these burners than those made with burners shut up in black boxes, carefully screened and protected from any irregular draughts or air disturbances.

The improved batswing burners may be briefly described as double burners, consisting of two batswings, the one capable of delivering say about 3 cubic feet of gas into a pear-shaped metal cup crowned with a second batswing burner, capable of delivering about 5 cubic feet of gas. By these simple means the amount of gas issuing from the top burner can at no time be greater than that allowed by the smaller burner, and it must therefore issue from the upper or larger burner at a *minimum* of pressure. Gas burnt under these conditions from batswing burners is known to give the maximum of illuminating power.

The photometrical results obtained fully bear out the correctness of these views. The illuminating power produced by these burners, consuming from 2 to 8 cubic feet of gas, ranges from four to thirty candles, and they may therefore be considered a considerable improvement upon burners of a similar kind hitherto constructed.

The larger flames will probably be found especially serviceable for burning in the open air and the smaller burners, giving from eight to fifteen candle light, for use in chandeliers.

[We can fully corroborate from personal observation many of the above statements with regard to the advantages of the Silber improved Argand gas burner. *Chem. Ed. Prac. Mag.*]

Silber Lamps and Large Gas Burners.—A. M. SILBER has succeeded in constructing a large concentric ring burner, which was recently tested at the Draper's Hall. A consumption of 86 cubic feet of gas per hour gave a much higher illuminating power than 300 cubic feet of gas consumed by 75

fish-tail burners. The light was placed outside the window upon the roof and lit up the coloured window. The advantages of this mode of lighting up large halls, &c. without producing heat and vitiating the atmosphere of the rooms will probably ensure a more general application of such large lights.

Improved ship lamps have also been constructed, *viz.*, mast-head, starboard and port lamps, burning colza oil without the aid of a glass chimney; these give a light more intense and pure than any hitherto obtained. The illuminating power is equal to about 26 candles; a burner of the same size fitted to a moderator lamp was tested and found to consume only 49 grains of oil for each candlelight, whilst an ordinary moderator lamp consumed from 65 to 66 grains of colza oil per hour for each single candlelight given, so that a saving of about 33 per cent. is effected by using the new burner.

Many attempts have been made, all more or less successful, to convey air to the burner through apertures somewhere in the lantern and from thence through tubes or chambers to the flame. These attempts have been wrong in principle, because the air track in all of them, however circuitous, has been continuous and unbroken.

If a rigid tube of any shape be taken and twisted into any number of turns and coils, it will be found on blowing into it that the forcible exit of air at one end will be simultaneous with its forcible entrance at the other.

In the same way a lamp with a continuous air track, if moving with a train or vessel, is exposed to sudden rushes of air upon the flame, and even if standing still, similar rushes will be produced by alterations in the force or direction of the wind, or by any other atmospheric disturbance.

The Silber ship lamp on the other hand receives its air supply from above, and neither movement, nor atmospheric disturbance, exerts much influence on the rate at which air descends through an aperture, this rate being mainly governed by that of the escape of the hot air, which has its outlet within the circle of ingress of the fresh supply; the cold air on entering is met, a few inches below the aperture which gives it admission, by a solid metal top or inner roof, which becomes heated when the lamp has been burning for a few minutes. A slit at one end of this inner roof allows the slightly warm and rarefied air to proceed onwards whenever it can find opportunity, that is to say, as rapidly as the exit of the exhausted or consumed air makes room for it. On its course it passes over the receptacle in which the supply of oil is stored, and keeps this at a moderate and regulated temperature, then between this receptacle and the inner side of the outer part of the lamp, and lastly beneath the chamber to which the burner is fixed, from whence it finds admission to the flame. The height of the wick is regulated without opening the lantern, and these lanterns, having no opening of any kind at their lower part, are especially valuable for use on board ship. With this arrangement there is no possibility of a continuous current of air being driven in any one direction; the air can only diffuse itself gradually and in proportion to the room made for it, through a succession of chambers, which effectually break up its continuity.

Moreover, the capacity of the chamber is so calculated that no more air can enter the lantern than is actually required for the maintenance of proper combustion.

The lights from these lamps can be seen for many miles, it is continuous, and requires no attention for sixteen hours or more. They have been practically tested with great success.

The dim and flickering lights usually noticeable in the saloons and cabins of even our finest sea-going vessels can now be replaced by somewhat similarly constructed saloon and cabin lamps, burning colza oil. Petroleum cannot be recommended for use on board ship.

Silber has also constructed an improved sleeping car lamp for Mann's sleeping carriages now used on the Continent. The atmospheric oxygen necessary for combustion is supplied from outside the roof, where also the products of combustion are dispersed, and when, as in a sleeping car, doors and windows are sometimes shut, the lamp ventilates the carriage, no matter whether lighted or not, and the globe of the lamp keeps about the temperature of the atmosphere inside the carriage; neither slamming of doors, rattling over points, great speed, nor passage through tunnels affects the light; and these lamps are so constructed that either colza, or so-called mineral sperm oil, can be burnt in them to equal advantage. The light which it produces is equal to 15 sperm candles.

Experiments on Fireproof Structures. — The National Safe Deposit Company have made the following experiments to ascertain the deflection of a protected rolled iron joist. A furnace was constructed 4 ft. wide, and 14 ft. 9 in. long internally. The top of the furnace was built to resemble the brick arched floor of a fire-proof building where the arches are supported on rolled iron joists—that is to say, the top was formed of two segmental arches 9 in. thick, bearing throughout the length of the furnace upon a rolled iron joist 10 in. deep and 6 in. wide, with a span of 14 ft. 9 in. This girder was protected by the fire-clay lining, so that no part of the surface of the metal could be attacked by the flames. In order the better to prove the efficiency of the fireclay casing on the girder, the arches themselves were built with fire-bricks, as is usually done in constructing a furnace. A coat of plastering would be applied to the fire-clay if it were used for casing the girders of a building, and therefore three-quarters of an inch of lime and hair was put on in this case; the top of the arches was then filled in with concrete a few inches thick, and the whole was left until sufficiently dry.

Upon the top of the furnace (representing the floor in a building) were then placed five tons of pig-iron—the total average load being 3 cwt. per foot super—which caused a deflection in the girder of three-sixteenths of an inch before the fire was lighted in the furnace. The fire was kept up for two and a half hours at furnace heat, dry pattern wood being used as fuel. In one hour the deflection of the girder was five-sixteenths of an inch; in two and a-half it was one inch and three-sixteenths; water was then injected into the furnace, and shortly afterwards the top of the furnace was removed, when the girder was found to be uninjured, and subsequently regained its straight form. This experiment showed the effect of continuous flame for a period of two and a-half hours at one spot.

The second experiment was like the first as regards the furnace—and only differed in the application of heat. In fires of actual occurrence, there is, following the first fierce conflagration, a period of dull smouldering of more or less duration. This it was desired to imitate, and therefore the girder was submitted to the continuous heat of a fire for an hour and a-half, and a smouldering heat was kept up for twenty-four hours, as far as the nature of the combustible permitted. It was necessary to replenish the fire occasionally; but this was rather in the disfavour of the girder. Add to this the fact that the side of the furnace gave way a little, and had to be shored up, and it will be seen that the conditions were rather more favourable for the "devouring element" than was at first intended. In this case, also, a load of five tons caused a deflection of the girder in its centre of three-sixteenths of an inch, increasing in nine hours to a maximum of $1\frac{1}{11}$ in. On putting out the fire twenty-six hours after lighting, and removing the load, the deflection was found to be three-eighths of an inch, and rapidly decreased as the girder became cool. The whole of the fire-clay around the girder —which was so arranged as to give a minimum thickness of two and a half inches—was found as originally placed, and quite uninjured. The plaster, of course, gave way. *Iron, June 6th*, 1854, p. 708.

Generation of Steam.—J. WATT gives the following table, showing the ultimate practical amount of work to be obtained from a given quantity of water converted into steam at various pressures:—

Pressures in		Cut-off.	Ratio of Expansion.	Mean Pressure.	Mean Effective Pressure, or Horse Power.
Atmospheres.	lb. per sq. in.				
1	14·7	·382	2·5	10·8	8·8
2	29·4	·2	5·	14·6	12·6
3	44·1	·138	7·1	16·6	14·6
4	58·8	·106	9·5	18·2	16·2
5	73·5	·086	11·6	19·8	17·8
6	88·2	·072	13·8	21·	19·
7	102·9	·062	16·	22·	20·
8	117·6	·056	18·	22·8	20·8
9	132·3	·049	20·4	23·6	21·6
10	147·	·044	22·7	24·2	22·2
11	161·7	·040	25·	24·7	22·7
12	176·4	·037	27·	25·0	23·2
13	191·1	·034	29·4	25·6	23·6
14	205·8	·032	31·	26·	24·
15	220·5	·030	33·	26·4	24·4
16	235·2	·028	36·	26·8	24·8
17	249·9	·026	38·3	27·1	25·1
18	264·6	·025	40·	27·4	25·4
19	279·3	·0236	42·3	27·7	25·7
20	294·	·0224	44·6	28·	26·

In the above table the first column gives the pressure in atmospheres, with the pressure in pounds per square inch to correspond. The second is the cut-off. The third is the ratio of expansion. The fourth is the mean pressure, and the fifth is the mean effective pressure or the horse-power.

The explanation is as follows:—When using steam of one atmosphere, and expanding it down to 5 lbs., the cut-off to effect this will be ·38 of the stroke, the steam will be expanded two-and-a-half times, the mean pressure will be 10·8, and the mean effective will be 8·8. When using steam of two atmospheres, these figures will be 0·2, 5, 14·6 and 12·6 respectively, and so on for each additional atmosphere. The fifth column also gives the comparative horse-power. For example: let an engine, working with steam of two atmospheres, expanding down to its lowest practical limit, or 5 lbs. above zero, be 12·6 horse-power, the same engine, working steam at eleven atmospheres, and expanding down to 5 lbs., would give out 22·7 horse-power, with the same consumption of fuel; or if the horse-power remain the same, the consumption of fuel will be reduced in the ratio of 22·7 to 12·6. *Paper read before the Liverpool Polytechnic Society.*

Artificial Ice and Refrigerating Machines.—DELLA BEFFA and WEST patent a peculiar arrangement depending on the use of ether, and consisting of a multitubular refrigerator as the ether is volatilized; a double-action air-pump, exhausting this vessel and pumping the ether vapour into a condenser; and a special condenser for the liquefaction of the ether vapours. *Bull Soc. Chim. Paris, xxi.* 380.

Prevention of Boiler Crust.—E. CREGAN has brought out "an improved composition for the prevention and removal of incrustations in boilers, pipes, tubes, valves, &c." The standard composition employed consists of a mixture of soft soap, 1 cwt.; malt spirits, 28 lb.; spirits of wine, 9 lb.; tar, 56 lb.; wood ash, 56 lb.; oak bark, 10 lb.; cocoanut oil, 18 lb.; linseed oil, 18 lb.; Irish moss, 7 lb.; potatoes, 14 lb.; soda, 10 lb.; fullers' earth, 5 lb.; potash, 4 lb.; Russian grease, 28 lb.; mineral paints, 18 lb.; and rain-water, 167 lb. The soft soap, tar, oils, grease, and mineral paint are boiled separately, and then mixed together. The spirit of wine is also boiled, the malt spirits being added to it when boiling. The wood ash, Irish moss, soda, fullers' earth, and potash are dissolved in part of the rain-water. The oak-bark is steeped for twenty-four hours in about six or eight gallons of the water, the bark being then thrown away. The various mixtures are then added together, and applied as a solution for effecting the purpose specified. *Iron, May 30th,* 1874.

§ 6. *Miscellaneous.*

Vitrifiable Colours.—DUMAS patents the use of mucilaginous substances, such as gum tragacanth, honey, grapesugar, fish-glue, glutin, glycerine, albumin, &c., instead of volatile essences to rub up colours with for the painting on porcelain, faïence, &c., &c., and the manufacture of pastes or sticks of colours thus prepared to be mixed with water for use instead of essences. *Bull. Soc. Chim. Paris, xxi.* 524.

India-rubber Solution.—Crude india-rubber is boiled for an hour with water to remove adhering fatty matters; it is then sliced by a circular knife revolving in water and dried in a warm room; finally it is dissolved in a mixture of benzol or turpentine free from fatty matters. The following proportions nswer well.

Benzol	50 parts
Essence of turpentine . . .	70 „
Caoutchouc in small fragments .	26 „

The solution must be thoroughly well triturated so as to render it homogeneous before its application to cloth, &c,; if required to be black a little fine lamp black is incorporated in the solution. *Bulletin Soc. Chim. Paris xxi.* 477; *from Polytechn. Notizblatt, xxviii.* 309.

Manufacture of Hydrocarbons.—A. SMITH and F. FIELD patent the following improvements in the decolourising of solid liquid hydrocarbons, and in the application of materials for that purpose.—These consist in the admixture of hydrated silicate of magnesia, lime, baryta, iron, or manganese, or the aluminate of magnesia with the solid and liquid hydrocarbons. One or more of these substances is mixed with the heated hydrocarbon to the extent of from five to fifteen per cent., the mass being stirred till the decolourisation is complete. The mass is then allowed to settle and the hydrocarbon is drawn off. The hydrocarbon absorbed by the decolourising material is recovered by boiling the latter with dilute acid, whereby the hydrocarbon is freed from the mass and immediately rises to the surface. The remaining liquid is allowed to settle and is neutralised with carbonate of soda, and is then re-precipitated with silicate of soda, in order to be used over again.

Quick-drying Oil-Paint Colours and Varnishes.—100 parts of water, 12 parts of shellac, and 4 parts of borax are melted at a gentle heat in a copper vessel, with continued stirring. The vessel is then covered, and the liquid allowed to cool; after which it is kept in well-closed bottles. This furnishes an excellent varnish, giving a beautiful and durable lustre, and is perfectly secure against the action of moisture and the air. To cause oil colours to dry rapidly, equal parts of this varnish and of the colour are to be rubbed up with oil, and spirits of turpentine added until the whole forms a homogeneous liquid mass. Objects coated with this mixture will dry completely in ten or fifteen minutes, according to the season or state of the atmosphere. *Chem. Centralbl.*, 1873, 159.

[*Note by Abstractor.*—Boracic acid has of late been very much used in the form of borate of manganese for purposes of rapidly drying oil colours and varnishes, but the manner in which it is employed is kept a secret. It is said to be cheaper than other chemicals used as dryers, and preserves the oil, does not discolour, and leaves no sediment. The cost wholesale is about 2*s.* 6*d.* per pound, and three quarters of a pound, when properly used, equal in their effect two pounds of other compositions.—R. G.]

Silvering of Glass Plates and Globes.—KRIFFENDORF recommends the following substances as silvering agents for glass plates: the double tartrate of potash and soda (2 per cent. solution); caustic ammonia; and a 12 per cent. silver nitrate solution. The reducing liquid is prepared by taking 900 cubic centimeters of the solution of the tartrate, and, after mixing, boiling strongly together, and while the steam is issuing violently from the flask, dropping in 20 cubic centimeters of the silver solution, and boiling for another ten minutes. This solution not only keeps, but seems to improve by age. The liquid is to be filtered from the precipitated silver as it is wanted.

The silvering solution is prepared by taking 900 cubic centimeters of distilled water, and adding 80 cubic centimeters of the silver solution and 100 drops of the ammonia solution, and filtering if necessary.

For silvering, equal volumes of the two solutions are to be carefully and separately filtered, and poured together into a flat glass dish to such a depth that the thoroughly cleansed plate shall be covered by a layer of at least one-tenth of an inch. Decomposition of the mixture takes place in ten minutes, and pure metallic silver is deposited on the plate, which is then washed, dried and varnished. For the purpose of silvering the interior of glass globes, &c., it is sufficient to pour in successive small quantities of the mixture, turning the vessel continually, so as to keep the whole surface wet uniformly. *Polyt. Centralbl.* 1872.

Glaze for Earthenware.—M. SALVETAT reports on Constantin's process, and recommends the following mixture:—

Silicate of soda at 50° . . .	100 parts.
Red lead	25 „
Finely powdered flints . .	10 „

as it is not attacked by vinegar or fatty matters, whilst the ordinary lead-glazes are frequently dangerous on account of the solubility of the lead compounds in such mixture. *Bulletin de la Soc. d'Encouragement,* 1874, *No.* 3.

Explosive Compounds.—H. L. WOOLF patents the use of sawdust, spent tan, &c., freed from impurities, and submerged for a few moments in nitric or sulphuric acid mixed with certain nitrates. The tan, &c., when prepared, is termed the wet incipient compound, and to form explosive compound No. 1, 40 lb. of this is mixed with 60 lb. of nitrate of baryta, ammonia, lead, or strontium. To this mixture is added 5 lb. of nitro-glycerine, absorbed by fine dry sand or infusorial earth, 20 lb. of soft wood charcoal or coal, 10 lb. of chlorate of potash, and 5 lb. of sulphur. The whole is then dried at a temperature of about 90° to 100° Fahr. For compound No. 2, 57 lb. of spent tan are mixed with a boiling saturated solution of nitrate of baryta, soda, &c., 15 lb. of sulphur, and 6 lb. of chlorate of potash, and dried at about 212° Fahr. Compound No. 3 contains 70 lb. of nitrate of baryta, 21 lb. anthracite, sea-coal, or soft wood charcoal, 7 lb. of nitrate of potash, 6 lb. of loaf sugar, 6 lb. of sulphur, and 2 lb. of chlorate of potash, first crushed, and then mixed together. This mixture is then damped with ordinary glycerine, sufficient to make its various parts cohere, and dried at about 212° Fahr. *Iron, May* 30, 1874.

Explosives.—NOBLE and ABEL have made a large number of experiments on the results of the explosion of gunpowder, with the following results.

The gunpowder operated upon in the experiments included five kinds, viz. pebble powder, rifle large-grain (cannon) powder,

fine-grain powder, and rifle fine-grain powder (all of Waltham Abbey manufacture), and also a spherical pellet powder of Spanish manufacture, specially selected for experiment as presenting considerable difference in composition from the English powders. The composition of the powders is shown in the following table :—

Components, per cent.	Pebble powder. Waltham Abbey.	Rifle Large-grain Waltham Abbey.	Rifle Fine-grain. Waltham Abbey.	Fine-grain. Waltham Abbey.	Spanish Spherical Pebble powder.
Saltpeter	74·67	74·95	75·0	73·55	75·30
Potassium sulphate	0·39	0·15	0·14	0·36	0·27
Potassium chloride	. . . .	. . . .	. . . .	. . . .	0.02
Sulphur	10·07	10·27	9·93	10·02	12·42
Charcoal: Carbon	12·12	10·86	10·67	11·36	8·65
Charcoal: Hydrogen	0·42	0.42	0·52	0·49	0·38
Charcoal: Oxygen	1·45	1·99	2·66	2·57	1·68
Charcoal: Ash	0·23	0·25	0·24	0·17	0·63
Charcoal: total	14·22	13·52	14·09	14·59	11·34
Water	0·95	1·11	0·80	1·48	0·65

The quantities of gunpowder exploded in the several operations ranged from 750 grammes to 100 grammes. The apparatus in which the charges were exploded consisted of a mild steel vessel of great strength, carefully tempered in oil, in the chamber of which the charge to be exploded was placed. The main orifice of the chamber was closed by a screwed plug, called the firing-plug, fitted and ground into its place with great exactness.

In the firing-plug itself was a conical hole, stopped by a plug, also ground into its place with great accuracy, and, for purposes of insulation, covered with the finest tissue paper. Two wires (one in the insulated cone, the other in the plug) were inserted, and joined by a very fine platinum wire passing through a small glass tube filled with mealed powder. By completing connection with a Daniell's battery, the charge could be fired.

There were two other apertures in the chamber—one communicating with the arrangement for letting the gases escape, the other containing the crusher-apparatus for determining the tension at the moment of explosion.

The pressures actually observed with this apparatus varied from 1 to over 36 tons per square inch.

The non-gaseous products of combustion assumed the solid form in a little more than two minutes after the explosion. By analysis the following results, amongst others, were obtained per gramme of powder :—

	Pebble.		R. L. G.		F. G.	
Pressure of explosion in tons per square inch	1·4	12·5	1·6	35·6	3·7	18·2
Percentage weight of solid products	56·12	55·17	57·22	57·14	58·17	58·09
Percentage weight of gaseous products	43·88	44·83	42·78	42·86	41·83	41·92
Potassium carbonate per gramme	·3115	·3098	·3007	·3755	·3454	·2499
,, hyposulphite	·1163	·0338	·1166	·0491	·0308	·1863
,, sulphate	·0843	·0658	·1171	·0487	·1409	·1220
,, sulphide	·0416	·1055	·0230	·0413	·0298	—
,, sulphocyanate	·0005	·0013	nil.	·0021	·0001	·0013
,, nitrate	·0027	·0011	·0032	·0011	·0005	·0011
,, oxide	—	—	—	—	—	·0173
Ammonium sesquicarbonate	·0009	·0004	·0003	·0009	·0009	·0002
,, carbon	—	—	·0072	—	—	—
,, sulphur	·0034	·0340	·0041	·0527	·0333	·0027
Total solid	·5612	·5517	·5722	·5714	·5817	·5808
Sulphhydric acid	·0134	·0084	·0166	·0077	·0154	·0081
Oxygen	—	—	—	—	—	·0006
Carbonic acid	·0519	·0473	·0303	·0356	·0416	·0258
Carbonic anhydride	·2577	·2770	·2597	·2750	·2512	·2718
Marsh gas	—	·0012	·0006	·0015	—	·0009
Hydrogen	·0007	·0005	·0005	·0003	·0010	·0005
Nitrogen	·1151	·1139	·1201	·1085	·1091	·1117
Total gaseous	·4388	·4483	·4278	·4286	·4183	·4192

The following table represents the pressures to a given density of the products of explosion in a close vessel :—

Mean density of products of explosion.	Corresponding pressure for pebbles and R. L. G. powders. *Tons per square inch.*	Corresponding pressures for F. G. powder. *Tons per square inch.*
·10	1·47	1·47
·20	3·26	3·26
·30	5·33	5·33
·40	7·75	7·74
·50	10·69	10.59
·60	14·39	14·02
·70	19·09	18·31
·80	25·03	23·71
·90	32·46	30·39
1·00	41·70	38·52

From the mean of several concordant results, it was found that about 705 gramme-units of heat are generated by the combustion of a gramme of each of the powders examined ; and from these data it is calculated that the temperature attained during the explosion is about 2200° C., this estimate, moreover, being shown to be confirmed by the behaviour of thin platinum wire and foil. When exposed to the temperature of explosion, *signs* of fusion being exhibited in every case, actual fusion being produced, however, in only one instance.

Assuming 57 per cent. by weight of the products of explosion to be non-gaseous and 43 gaseous, the relation between the pressure and the density of the products of combustion is expressed with considerable nearness by the equation

$$p = \frac{\delta}{1 - a\,\delta} \times \text{const.}$$

when a is experimentally found to be 0·65. The authors also deduce the following results from these experiments.

At the moment of explosion, the fluid products of combustion occupy a volume of about 0·6 cubic centimetres, whilst the permanent gases occupy about 0·4 cubic centimetres, the latter occupying at 0° and 760 millims, about 280 times the bulk of the powder ; the tension of the products of combustion, when the powder entirely fills the space in which it is exploded, is about 6,400 atmospheres, or 42 tons per square inch.

When powder is fired in the bore of a gun, the products of explosion, at all events as far as regards the proportions of total solid and gaseous matters, are the same as in the case of powder fired in a close vessel.

The work on the projectile is effected by the elastic force due to the permanent gases.

The reduction of temperature and pressure due to the expansion of the permanent gases is in a great measure compensated by the heat stored up in the liquid residue.

The total theoretic work of gunpowder, when indefinitely expanded, is about 332,000 gramme-metres per gramme of powder, or 486 foot-tons per lb. of powder.

With regard to one or two other points, to which the authors specially directed their attention, they consider that their results warrant them in stating that :—

Very small-grain powders, such as F. G. and R. F. G., furnish very decidedly smaller proportions of gaseous products than a large-grain powder (R. L. G.) ; while the latter, again, furnishes somewhat smaller proportions than a still larger powder (pebble), though the difference between the totally gaseous products of these two powders is comparatively inconsiderable.

The variations in the composition of the products of explosion furnished, in close chambers, by one and the same powder, under different conditions as regards pressure, and by two powders of similar composition, under the same conditions as regards pressure, are so considerable, that no value whatever can be attached to any attempt to give a general chemical expression to the metamorphosis of a gunpowder of normal composition.

The proportions in which the several constituents of solid powder-residue are formed are quite as much affected by slight accidental variations in the conditions which attend the explosion of one and the same powder in different experiments, as by decided differences in the composition, as well as in the size of grain of different powders.

In all but very exceptional results, the solid residue furnished by the explosion of gunpowder contains, as important constituents, potassium carbonate, sulphate, hyposulphite, and sulphide, the proportion of carbonate being very much higher and that of sulphate very much lower than stated by recent investigators.

The amount of heat communicated to the envelope of a gun varies from 35 per cent. of the total heat in the case of a small arm, to about 3 per cent. in the case of an 18-ton gun ; complex formulæ are given, indicating the relation between the tension of the products in the bore of a gun and the volume occupied by them ; and between the work done, and the temperature attained during the expansion of the products. *Proceedings of the Royal Society*, 1874. *No.* 153.

Improved form of Grove's Battery.—H. YEATES proposes the following arrangement : The cells are fixed in a frame, provided at the top with a loose wooden rim surrounding the cells and reaching about a quarter of an inch above them. Upon this rim brass strips are placed, to which the zinc plates of one cell are permanently fixed, and the platinum plate of the next cell.

The advantage of this arrangement is the absence of the binding screws, so that when the cells are filled, the plates can be rapidly introduced and taken out again. *Dingler's Polytech. Journ. ccvi.* 304.

Bleaching Paper Pulp.—P. DE WILDE finds that an admirable material for paper pulp can be obtained from straw, esparto grass, wood shavings, &c., by first treating the moistened material with gaseous chlorine, whereby a yellowish orange tint is communicated, then boiling with water, whereby much hydro-

chloric acid is dissolved out, and finally treating with a caustic soda ley containing one-tenth as much soda as the weight of original matter operated on ; the liquor browns, whilst the matter softens and the fibres become disintegrated ; a grey pasty substance is thus obtained which can be bleached readily by chloride of lime (1 litre of solution at 1° B. for 100 grammes of original matter) yielding fibres of silky lustre and irreproachable solidity.

Notwithstanding a considerable saving in bleaching powder and in alkali effected by this process, it does not seem to be of a very practical nature ; the cost of the gaseous chlorine is considerable, the manipulations are much more complex than in the ordinary process of heating under pressure with soda ley, whilst the regeneration of the spent alkali is less complete. *Bulletin Société Chimique de Paris, xxi.* 479 ; *from Bulletin de l'Académie royale de Belgique, January*, 1874.

Use of Timber in connection with Mechanical Work.—J. G. LYNDE stated that for all ordinary purposes the kind of timber most used for pattern-making, and in temporary structures, such as travelling cranes, staging framework, and platforms for the erection of bridges and similar work, was fir, either American or Baltic, the nature and properties of the different descriptions of which, as usually met with in our market, he proposed shortly to describe ; but before doing so it might be interesting if he gave a very slight sketch of its introduction to this country. Previously to the colonisation of America our supply of fir timber was obtained from the countries on the coasts of the Baltic, of which Norway, Russia and Sweden were the first resorted to. The colonisation of America, however, soon opened a large and valuable field for obtaining timber of similar growth, the two Canadas especially yielding large supplies of a very fine quality. More recently a supply of the same kind of timber had been obtained from Savannah and the adjacent states of America, and efforts were now being made to open a trade with California, where was to be found some of the finest red wood ever brought into our market. Fir timber might be divided into three distinct classes, known by the colour of their wood—by white, yellow and red. American spruce deals belonged to the first-named class, and were principally used for joists and bearing timbers in common houses as well as for scaffolding in the erection of machinery. There was so much of a very inferior quality of this kind of timber that it was necessary a very practical knowledge of it should be acquired by those under whose directions it was used, as serious accidents frequently happened when it was misapplied. Baltic white deals were wood of a very fine texture, and used principally for the same purposes as the American spruce deals. This timber, would not, as a rule, bear so great a load as the American, but it was much less liable to warp from change of temperature. Both these kinds of timber were specially liable to decay if placed in warm and moist situations, fungi speedily forming on them, and causing what was commonly known as dry-rot ; and when once this had been commenced, the wood was no longer to be depended upon. These woods were both extensively used for packing-cases for machinery, and for this purpose were quite as good as more expensive timber. The next class of timber to which he would direct attention was the American yellow pine. The timber was imported in logs, and cut up into boards or scantlings in this country ; like the white wood, this timber was practically non-resinous ; it was of a fair texture, and when not exposed to damp was durable. It was much used for building purposes, especially for joiners' work that was covered with paint. As a bearing timber it had a peculiar quality—viz., that it retained its form with a permanent load ; whereas many kinds of timber when loaded continued to deflect for years, although the load might not be greater than they might safely be required to bear. Unless, however, this wood was properly treated from the log, its valuable quality of retaining its form was materially impaired. The log should be opened and cut into boards in the autumn, and exposed to the weather through the winter ; in the spring it should be removed into the drying shed, and thence into a room having a corresponding temperature with that wherein it was to be stored when finished for at least one month before being worked. On no account should this wood be placed in a stove, as in its removal from a high temperature it would always be liable to change its form. There were many qualities of yellow pine, and their quality varied very considerably. Next, referring to the red wood, he said this timber was imported both from America and the Baltic in the form of both logs and deals. There were several varieties of red deals, each possessing its own peculiar character ; but all of them more or less valuable on account of their power to resist atmospheric changes and the action of moisture. It was, therefore, much used in engineering works for piles and timber framing exposed to the weather, railway sleepers, and all places where it was necessarily shut out from a free passage of air. It was also less liable than any other kind to dry-rot. The timber imported from Sweden was generally of a very inferior quality and of small size ; it was very liable to crack if exposed to the sun, causing what were known as "sun strokes." The custom at all the ports on the arrival of the timber was to put the logs into water to prevent this. The pitch pine imported from the Southern States of North America, Savannah, and Pensacola, was of a strongly resinous character, but had a great tendency to dry-rot, especially if it was placed in contact with fresh mortar and lime. This timber was, therefore, unfit to be built into walls as bearing beams, unless the ends were placed in cast iron boxes, or were otherwise protected so as to allow a free circulation of air round the ends of the beams. Many samples of this timber had a beautifully waved grain, and would take a high polish, and these were selected and used for ornamental joiners' work. One peculiarity in connection with all red wood was, the varied qualities found in the same log ; the lower part of a tree might be exceedingly good, while the upper part might be very inferior. From the remarks he had made, it would be seen how impossible it was to fix any arbitrary formula that would be applicable for calculating its strength, the quality being so variable that the same formula would not apply in any two cases. He had tried some experiments on a sufficiently large scale to guide his own judgment, and he found that for a very good and selected sample of Baltic timber the following simple formula for beams might be relied upon :—the breaking weight in the centre equalled the product of the breadth with the square of the depth multiplied by 15, and divided by the length in feet ; and for an ordinary sample of timber he usually took the safe load in the centre in tons equal to the product of the breadth, with the square of the depth multiplied by ·03, and divided by the length in feet. *Presidential Address to the Manchester Scientific and Mechanical Society.*

The French Metre.—An international commission has been formed in France, for the supply and propagation of standards of the mètre measure, and of the kilogramme. Orders for forty-five standard mètres, at a cost of 3,500 fr., and for the kilogramme at a cost of 1,500 fr., have been received. It certainly would be a great boon to all, if some good universal standard of measure and weight were internationally adopted ; and certainly the French decimal system of weights and measures is infinitely superior to the English, or to any which is not arranged on a decimal basis.

The commission is taking the utmost care to ensure perfect uniformity in its standards. All the standards are to be made from a single ingot of iridised platinum. The homogeneity of this ingot is ensured by first casting the alloy of platinum and iridium in pieces of 10 kilogrammes. These are then cut up, mixed, and re-cast in pieces of 80 kilogrammes. These latter are drawn out in bars, are cut up and mixed, and finally cast in a single ingot. The platinum is worked by means of an oxy-hydrogen blast, and the iridium was prepared by a wet method in the laboratory of M. St. Claire-Deville. Very suffocating and dangerous fumes of osmium are disengaged during the process. *Iron, July 4th*, 1874.

INFLUENCE of Temperature on the Elastic Force of Springs.—F. H. WENHAM has made experiments on the deflection and set of springs, at temperatures up to 500°. He finds, amongst other results, that metals whose elasticity is derived from condensation of material lose their elasticity equally for equal degrees of heat ; whilst steel, the elasticity of which results from heat (in the tempering and hardening processes), obeys a different law. Possibly this may explain why a gold alloy is used by some chronometer makers in lieu of steel for the balance spring, a secondary compensation being probably thereby rendered less essential. *Paper read before the British Association, Bradford.*

ALLOY for Music-printing Plates, &c.—JEAN patents the preparation of the following alloy, to which he gives the name "heterogeneous metal" (métal hétérogène) :—

Tin	10 parts.
Zinc	12 „
Antimony regulus	3 „
Copper	1 „
Lead	74 „
	100

Bull. Soc. Chim. Paris, xx. 327.

NOTES UPON FARM MANURE PITS, SHEDS, AND TANKS.

IN the second number of this journal, on pp. 97 and 98, we gave, under the above heading, a few remarks and illustrations upon this important subject. What we gave, in place of exhausting the subject, may be more accurately characterized as only opening it up, and stating the elementary truths or principles upon which it is based. There is, we believe, no subject which carries with it so much that is of practical importance to farming than the proper care, treatment, and use of manure. Its importance is displayed in the general concurrence of all practical men in the absolute accuracy of the proverb, which, worded rather more roughly than elegantly, tells us that, "without muck there is no meat," or as the continentalists put it in periphrastic style, which sounds nicer, "No corn no cattle, no cattle no manure, no manure no crops." Next to the preparation of the land stands the proper use and treatment of manure, and yet it will be somewhat strange for the reader not initiated into the art and mystery of agriculture, to be told that what the proper use and treatment is, there is a

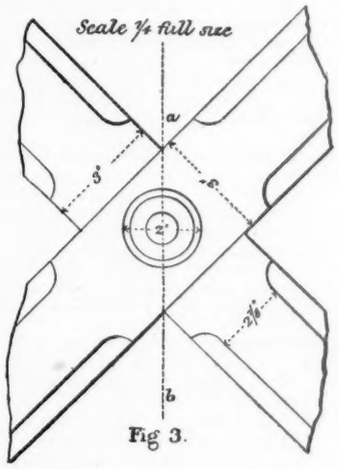


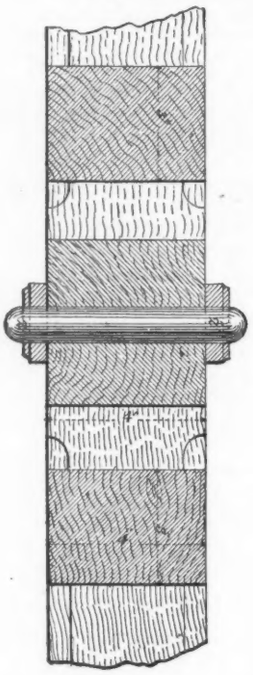
Fig 3.

wonderful diversity of opinion amongst practical men, and while our leading scientific authorities are discussing the pros and cons of the subject, and while our leading practical men are doing their best according to their lights, it is a pity to have it to state, that a large number of men who pride themselves above all things on being "practical" are groping their way without any light at all, thinking, rather, that they do not need light, and that the old ways are the best ways; they saying "Our fathers before us did as we do, are we wiser than our forefathers?" The results, however, of recent practice, and of the dissemination of sound information on the subject by the leading agricultural journals, has done, and is now doing, a vast deal of good in reducing the evils of this state of matters, and is likely in time to make them a thing of the past, as they deserve to be. Meanwhile the position of matters is this, that while, whatever may be said of the proper use of manure on the field, as regards the proper treatment of it in the yard, this is the exception, not the rule. Comparatively seldom indeed are appliances met with in the farm yards of the kingdom, by which manure is cared for and treated on the principles set forth by our leading scientific and practical authorities.

It will form the subject of a useful paper to discuss, briefly as may be, these principles; but this we defer to a more convenient opportunity, meanwhile giving as a practical supplement to the paper alluded to at the beginning of this, working drawings of a "covered dung-pit and liquid manure tank," which we have found to answer well in practice. Although the plan in fig. 1 shows but a small pit—capable, nevertheless, of holding a considerable weight of manure—it is obvious that it may be enlarged to meet the requirements of a more extensive supply of it. In the first paper, vol. i. p. 98, we have given approximative rules to find the dimensions of dung-pits and tanks, and at the conclusion of this we shall perhaps extend these.

In the structure now under illustration, liquid manure is brought from the cattle houses, stables, &c., to, in the first instance, a small settling tank, *a a*, provided with a stone cover, *b* (see longitudinal section, fig. 5, to be given in a future number). This tank allows all solid matter to be deposited, the overflow

Fig. 4



being comparatively pure, and passing away from the settling tank by a pipe, *c c*, at its upper part, this pipe leading directly to the large tank, *f f*, in which it is stored up till wanted. When a supply is required, either to moisten the dung in the pit above (see remarks upon the treatment of dung, hereafter to be given) or to be led to the fields, it is taken out from the tank by means of a liquid manure pump, which may either be a permanent fixture attached to the platform of the stage for pump, shown in plan fig. 1, or it may be made so as to "ship" and "unship" as required. We have found the form of pump made by Richmond and Chandler, of Salford, work excellently in practice, and not liable to get out of repair. The liquid manure is led to the pump by the large pipe, *d d*, figs. 1, 2, and 5. Fig. 2 is a transverse section on the line A B, in plan fig. 2. In fig. 3 we give front elevation of the woodwork at *a a* in fig. 2, being the part where the two bars cross to fill up the space between the vertical uprights of the rail with which the brick well of dung-pit is crowned. In fig. 4 is an inside view of the edge or narrow side of the part in fig. 3.

MINERAL PRODUCE OF RUSSIA.—The "Tableaux Statistiques de l'Industrie des Mines de Russie en 1871," which was published by Mr. Skalijowsky in connection with the Vienna Exhibition, contains the following data with regard to Russian mining industry. In 1871, the number of mines owned by Russia, and producing gold, was 979; platinum, 6; silver-lead, 21; copper, 76; iron, 1,174; zinc, 6; cobalt, 1; tin, 1; coal, 326; pyrites, 1; chrome, 6; rock salt, 4; besides 697 naphtha pits. Their yield was from 17,000,000 tons of gold sand, 86,406 lb. of gold, from 168,000 tons of platinum sand, 4,504 lb. of platinum, 35,120 tons of silver-lead ore, 100,365 tons of copper ore, 820,000 tons of iron ore, 42,400 tons of zinc ore, 10½ tons cobalt ore, 8,000 tons pyrites, 817,000 tons of coal (black coal and brown coal), 22,000 tons of naphtha, 7,000 tons of chrome iron ore, and 455,000 tons of rock salt. The smelting works of Russia produced from these raw ores—silver, 29,000 lb.; lead, 1,740 tons; copper, 4,200; tin, 8; spelter, 2,700; pig-iron, 354,000; iron castings, 30,000; wrought iron, 241,500; steel, 7,000; copper sheets, 350, and zinc sheets, 500 tons; and material for 11,255,000 roubles. The works gave employment to 266,300 men.

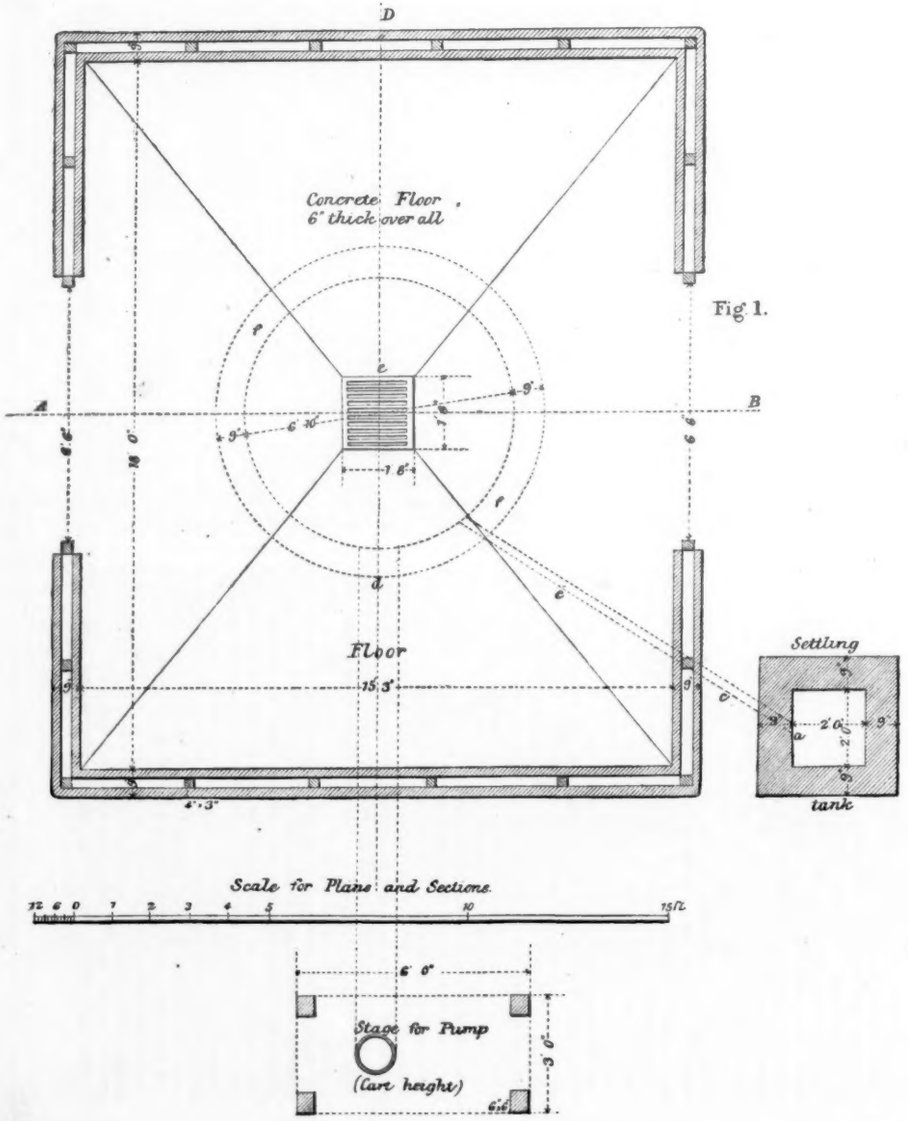

D
Concrete Floor
6" thick over all
e
f
A
B
d
c
Floor
15' 3"
Settling
tank
Scale for Plans and Sections.
Stage for Pump
(Cart height)

Fig 1.

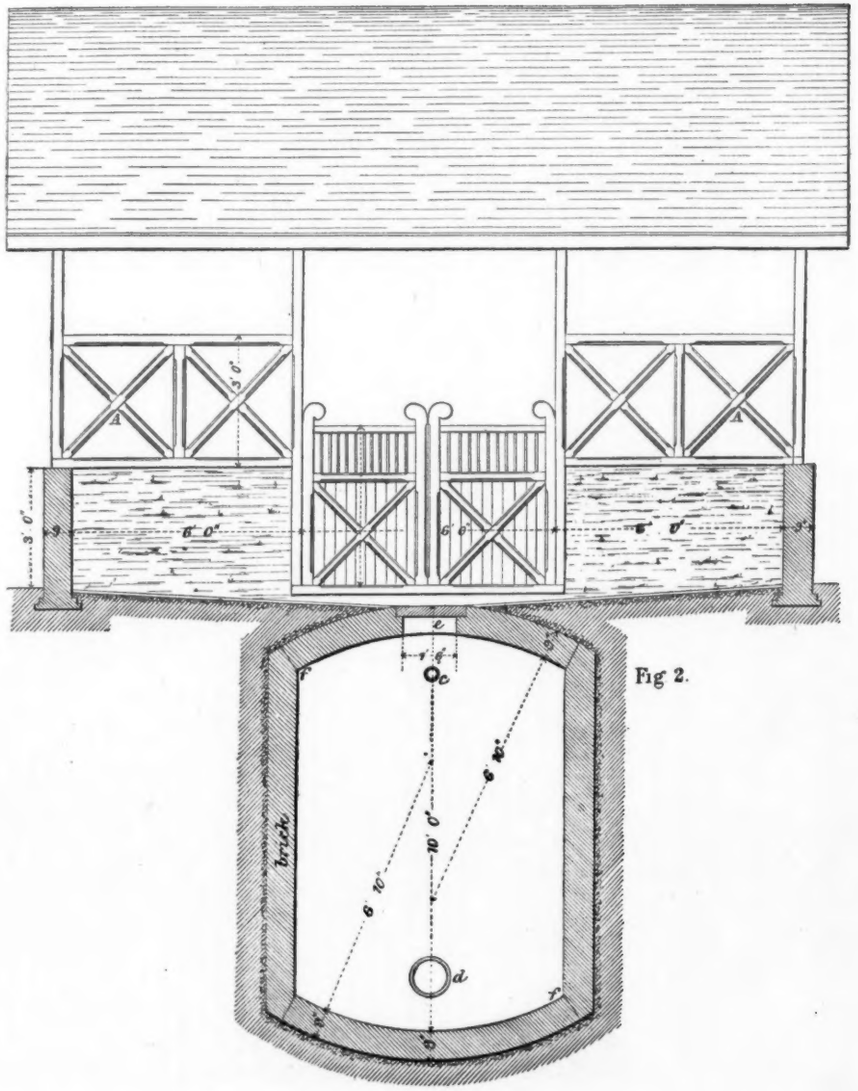

e
c
d
f
brick

Fig 2.

SUBSTITUTES FOR LEATHER, CARPETING, AND PARCHMENT.

IT might appear at first sight that such substitutes as those denoted by the above title cannot have much in common, much companionship or family likeness. But in truth they resemble one another in this—that many ingredients, when mixed and melted, can be spread out in a thin layer which, well dried and pressed, has a toughness and suppleness analogous in some degree to leather. In other instances the mixture can be used as a medium between carpet and floorcloth, possessing some of the characteristics of both. In others, again, paper can be so treated as to possess many of the qualities of parchment. In most of these cases cheapness is one of the features aimed at.

Several years ago an imitation leather was introduced, comprising a curious mixture of textiles and other substances. The foundation or backing consisted of a thin canvas made of cotton, linen, or woollen, or even a felt; and on this was spread a composition of glue or size, boiled linseed oil, lampblack, white lead, and pipeclay. The layer dried into an elastic coating or varnish, which enabled the canvas to be used for many purposes in a similar way to leather. Boiled linseed oil, spread out thin, is known to assume a condition of singular toughness, which it will retain for a lengthened period; and by a particular mode of treatment it becomes additionally oxidised. One kind of cotton cloth, spread with layer after layer of oil so treated, has been much used as a substitute for leather, or as a waterproof material for carriage hoods, seats, gaiters, shoes, &c.

One of the best inventions of this kind is known by the name of *Linoleum*, a designation which tolerably well denotes its chief characteristic. In 1849, MM. Niklés and Rochelder independently discovered that chloride of sulphur will solidify oil, and render it subservient to many new uses. Ten years later M. Perra communicated to the Academy of Sciences at Paris a description of a mode by which this could be practically effected in the mixing, melting, and spreading of the ingredients. Varying degrees of consistency, toughness, and elasticity can be produced by varying the proportions of the ingredients. Thus, 100 parts of linseed oil to 25 of chloride of sulphur produces a hard and tough substance; by lessening the proportion of chloride to 15 parts, a suppleness something like that of india-rubber results; while 100 parts of oil to 5 of chloride gives to the mixture a pasty consistency, which enables it to be dissolved well in oil of turpentine. Mr. Walton, extending and amplifying these experiments, found that heat alone will, in a particular mode of application, impart to the linseed oil much of the same characteristic as it derives from the chloride of sulphur. The *modus operandi* is peculiar. Well-boiled linseed oil is applied as a layer to a smooth surface of wood or glass; when dried this is succeeded by another layer, and so on three or four times until the required thickness is produced. The hardened film, when removed from the wood or glass, is found to be almost as elastic as india-rubber; and strength can be added to this elasticity by increasing the thickness, but only within moderate limits. If a little oxide of lead is added during the heating, the drying of the film of linseed oil is somewhat expedited. The film is not a finished product; it is in the nature of a raw material, which can be applied to various useful purposes according to the mode in which it is treated. Some of these we will enumerate. (1.) When dissolved in naphtha it is valuable as a waterproof varnish. (2.) When crushed and worked thoroughly between heated rollers, it becomes a substitute for india-rubber or gutta-percha in some of their applications. (3.) When, in the form of mastic or varnish, it is applied to any one of many kinds of cloth, the product is found useful as a material for waterproof textiles, felt carpets, carriage-aprons, waggon and cart-sheets, nursing-aprons, water-beds, tank-linings, table-covers, &c. (4.) When prepared to such a consistency as to be applied as paint, it is useful for ships' bottoms, and for iron and wood generally. (5.) When used as a cement, it possesses some of the adhesive qualities of marine glue. (6.) When hardened as much as heat can harden it, it may be treated like wood, bone, or horn; filed, planed, turned, carved, or polished, for knife and fork handles, mouldings, and ornaments of various kinds. (7.) When brought to the consistency of dough or putty, it may be pressed into carved or embossed moulds, for the production of a multitude of decorative articles. (8.) When prepared to a definite degree of hardness, wrought to the shape of a grinding wheel, and the edge touched with emery, it becomes a good cutter. (9.) Lastly, it is used in the preparation of the material more specially designated by the name of *linoleum*. To produce this the dried films of linseed oil are mixed with ground cork, and pressed, by means of rollers, on breadths of canvas; the other surface of the canvas receives a coating of paint made from the same oil. One of the features of value in the substitutes here under notice, is the facility, with suitable modes of treatment, of taking colours and dyes, designs and gilding, polish and enamelling, in addition to the possession of toughness, suppleness, and durability in a considerable degree. So far as linoleum is concerned, these surface adornments are confined to printing with paint, in the manner of floor-cloth. The manufacturers claim that this linoleum possesses qualities superior to those of ordinary floor-cloth.

The American *leather cloth* has had an amazing success, in its application to table-covers, black bags, and numerous other articles. Several different kinds have been patented; but the following is the mode of making the principal variety. The woven cloth, be it of cotton, flax, jute, or hemp, or a union of two or more of them, is drawn in by steam power between two cylinders or rollers, the uppermost of which is kept constantly wetted with a well-prepared composition, a mixture of oil, resin, lampblack and other substances. The composition flows upon the cloth, and is equalized by the pressure of the upper cylinder upon the lower. From the cylinders the cloth is wound upon a drum formed of wooden bars so arranged that the successive plies of cloth shall not touch one another. When the whole piece has been wound upon the drum, the latter is placed, with the wetted cloth upon it, in a drying chamber. After exposure to heat for a sufficient length of time, the cloth is removed from the drum, smoothed with pumice stone, and passed a second time between the cylinders, to receive a second coating of the mixture; and so on five or six times over, each coating being dried and smoothed before the next is applied. Then follows a final process of pressing, so managed as to produce an imitation of the surface and appearance of natural leather. Such a surface may easily be made to receive the adornments of colour and pattern, if so desired. The United States army, during the late struggle of civil war, had caps, leggings and knapsacks made of some such leather cloth as is here described. Similar in principle, but differing a little in detail, is the mode followed in a large leather cloth factory established near London. Linseed oil heated in large coppers to a temperature determined by experience, is set aside to cool, and is then mixed with turpentine, lampblack and other ingredients, to form a kind of paint or varnish. Unbleached cotton cloth, woven in different widths according to the purpose to which it is to be applied, is made smooth by calendering, and passed over a cylinder or roller. A layer of composition, applied during this passage, is scraped with a peculiar kind of knife to render it as smooth and equable as possible. After drying in a heated chamber, the cloth is passed between rollers covered with pumice dust, by which the composition is rubbed smooth. When these alternate processes have been repeated four or five times, the cloth receives three or four coatings of a kind of enamel paint well fitted to receive various kinds of ornate finishing—such as (1) passing between rollers peculiarly grooved on the surface, to produce a grain like that of morocco leather; (2) receiving a pattern in relief by passing between embossing rollers; or (3) receiving a pattern printed in gold and colours, to form furniture hangings and table-covers.

An article called *moleskin table covering* came much into favour ten or a dozen years ago. It consisted of a light cotton or linen fabric printed in oil by block or cylinder with lively and brilliant patterns and colours. It has been used as panelling for railway carriages and steamboat saloons.

There are many other kinds of imitative leather, or rather substitutes for leather, consisting of oily mixtures applied to the surface of woven cloth. Such is Szerelmy's. This inventor varies the kind of cloth, according to the sort of article to be produced, alternating between cotton, linen, woollen, silk, and alpaca, according as he wishes to obtain substitutes for morocco leather, calf leather, enamel leather, or simply waterproof cloth. Beard and Downing's artificial leather consists of an open linen fabric, upon which a fleece of cotton or wool fibre is cemented by a composition of oil and resin, pressed down by rollers; two or more successive layers of fleece and cement give an increased thickness to the substance. To render the imitation still more complete, ground leather is sometimes mixed with the fleece. The surface will receive any of the usual oil colours. There is one kind of leather substitute which is in fact real leather, applied in a cheap form. This is Seager's, which consists of leather parings, scrapings, scraps and odds and ends reduced to a pulpy mass, and moulded into useful and ornamental articles, such as machine-bands, buckets, picture-frames, architectural ornaments, &c.

Leather cloth, among other useful applications, is employed in France and in Saxony for making school-room maps, cheap

and durable; they are printed in white on a black ground, and are left to be filled up by the pupils.

We have hitherto treated of woven cloth covered with a preparation of linseed oil, or oil combined with glue, resin, turpentine, lampblack, or other substances. But we have now to mention an agent which has played an active part in the preparation of artificial leather. We speak of *india rubber*, the peculiar elasticity and suppleness of which render it well fitted to subserve such purposes. The facility, also, with which it can be dissolved in naphtha and other kinds of essential oils and spirits renders it valuable as a waterproof varnish or coating. Dunn's patent imitative floor cloth owes its principal quality to the presence of this substance. The india rubber, mixed with cork shavings and raspings, cotton and woollen and other fibres, is applied to one surface of a canvas back or foundation. When properly pressed smooth, it is finished off with an embossed pattern. Messrs. Hancock's substitute for leather, one of the earliest kinds invented, consists of a felted fabric or canvas of flax, cotton, jute, or other material, covered with several successive coatings of dissolved india rubber; each layer well dried before the next is applied. Gundy's substitute is another variety, applicable for covering coach tops, and many useful and ornamental purposes in the arts. A clever imitation of morocco leather is produced by applying a layer of india rubber or gutta percha to a surface of cotton cloth; the surface is then corrugated in the manner of morocco leather, stained, and varnished. The material thus produced is elastic, durable, cuts up well owing to the width in which it can be made, and is very much cheaper than real morocco. Another ingenious variety is Messrs. Spill's *vegetable leather*, containing naphtha as well as india rubber in the composition applied to the cloth or backing. It is sometimes made in pieces so large as fifty yards long by a yard and a half wide, and is hence applicable to a considerable diversity of purposes, besides the smaller uses for soldiers belts, buckets, harness, bookbinding, &c. It is a cheap substitute for many different kinds of leather. By varying the number of cemented layers the substance may be manufactured in different thicknesses. Jeune's *leather substitute*, another of these varieties, consists of a cement or mastic of india rubber applied to cloth or felt, and then pressed down upon a layer of leather. A splitting machine is employed to split up an ordinary hide of leather into a number of extremely thin films; the cloth or felt, cemented to it, facilitates this splitting; and there is a new cementing of cloth after each passing through the machine. The resulting substance, therefore, is really leather on one surface, cloth or felt on the other; and the leather surface may be dyed, painted, gilt, embossed, or enamelled in various ways.

The somewhat over-learned name of *Kamptulicon* is given to a material used as a substitute alike for carpeting and for floorcloth. The word means flexible or supple, and the material is a kind of flexible or elastic floorcloth. Kamptulicon was invented or introduced in 1843, but was not much known until the late Sir Charles Barry caused it to be used in the long corridors of the new Houses of Parliament. Like some of the other substances described above, it consists of india rubber and ground cork mixed with oxidized linseed oil. The cork, reduced to a kind of fine sawdust, is kneaded up into a sort of dough with the other ingredients, kept soft by heat and rolled into sheets by passing between steam-heated cylinders. The sheets, when cold, can be used at once, or can be painted or printed with ornamental designs, in the manner of floorcloth; the surface takes colour well, and, if necessary, would doubtless take varnish or polish well. This is not a material with a cloth backing; the whole substance is made of the three ingredients named. All the substitutes for leather are cheaper than real leather; but kamptulicon is not cheaper than floorcloth. It claims to possess qualities which are wanting in that substance, and to combine many of the advantages of carpet with floorcloth. Its elasticity to the tread makes it agreeable to walk upon; it is also noiseless, and on that account well adapted for hospital corridors and other situations in which quiet is desirable. The floor of the admirably-planned Reading Room at the British Museum is covered with this material. Kamptulicon is also impervious to damp, and thereby well suited for damp stone floors, which would soon bring carpeting and even floorcloth to decay. The inferior kinds are said to consist of the two cheaper ingredients only, the india rubber being conspicuous by its absence. Gutta percha is sometimes used as well as india rubber.

The last of the substitutes which we propose to treat, that of parchment, differs materially from those which have hitherto engaged attention; although the substance produced, known as *vegetable parchment*, resembles the rest in its remarkable leather-like toughness. It is in fact paper, the fibres of which have undergone considerable change of character by chemical treatment. One of the first known kinds was invented by Messrs. Montgolfier of Paris, who so modified the texture of thin paper as to make it applicable to many of the same purposes as the so called gold-beater's skin. Mr. Gaine's vegetable parchment, introduced in 1854, and described before the Royal Institution by the Rev. J. Barlow in 1857, is better known in this country. Very little more seems to be necessary than to dip a sheet of paper into sulphuric acid. That paper can be greatly changed in character by the application of acids and alkalies, has been shown in Kuhlmann's pyroxidized texture, Pelouze's gun-paper, and other products long known in the arts; but Gaine's vegetable parchment derives its excellence from the observance of a particular degree of strength in the acid employed, which he seems to have been the first to ascertain. Very strong sulphuric acid is diluted with half its bulk of water; a sheet of paper dipped into this liquid almost immediately changes its character. It becomes tough, hard, and fibrous, without any alteration of weight. It preserves a writing surface little different from that of paper, and far better than that of parchment made of animal membrane. It receives oils and varnishes freely, and bears rubbing better than any kind of paper. It will serve as a substitute for vellum in bookbinding; as a material on which policies, certificates, indentures, &c. may be engrossed; and as a covering for jars, bottles, and canisters of various kinds. The conversion of ordinary paper into this singular kind of parchment can be effected even when the paper has been printed. So strong is this material, that a strip seven-eighths of an inch in width, and in the form of a ring, has been known to bear a suspended weight of 92 lbs.; although the strip itself only weighed 23 grains. The paper is in the unsized state when dipped in the acid, and the immersion lasts only a few seconds. Sulphuric acid rises in temperature when water is added; but the operator allows the mixture to cool down again before the dipping takes place. So far as is known, no actual chemical change is produced; but a molecular change evidently occurs, the material assuming a transition or medium condition between those of cellulose and dextrine.

Manufacturers were not slow in giving practical value to this invention. Messrs. Delarue introduced it in various forms. In some respects, the new material is preferable to animal parchment for engrossing legal and other documents upon, as it is less liable to attack by insects. It is well adapted for the use of engineers, surveyors, and mechanical draughtsmen, as it can be made as thin as tracing-paper, and will bear exposure to wet without injury. Mr. Crookes, the chemist and photographer, has made experiments to determine the suitableness of vegetable parchment for photographic purposes. He prepared acid solutions of the requisite degree of strength, and steeped slips of paper photographs in it. The colours and tints, even in the delicate half tones, remained intact; the uniform contraction of the paper added to the sharpness of the picture; the paper became much stronger than before, bearing much rough handling without tearing; the non-albumenized photographs acquired a peculiar glossy appearance, which gave a rich finish, without glaze; while the picture could be washed with soap and water, and rubbed with a cloth, without injury. Whether photographers have more recently verified these experiments (which were made several years ago) we are not aware.

About the year 1855, Captain J. H. Brown patented an *artificial parchment* which was really of animal origin, like other parchment. Parings and cuttings of raw hides, reduced to pulp, were made into thin sheets possessing many excellent qualities. As this was done in a building formerly used as a paper-mill, near Romsey in Hampshire, and as much of the apparatus employed resembled that used in the paper manufacture, the excise proposed to tax it; but a court of law decided that the substance produced was neither paper nor parchment.

We may conclude with a notice of paper rendered waterproof, although not imbued with the other qualities of parchment. Professor Muschamp, of Würtemberg gives a recipe for the requisite waterproofing liquid: 24 ounces of alum and 4 ounces of white soap are dissolved in 2 pounds of water; 2 ounces of gum Arabic and 6 ounces of glue are dissolved in other 2 ounces of water; the two solutions are mixed, and the sheets of paper dipped in them. When dried by hanging up, and pressed between rollers, the paper thus prepared becomes well suited for various purposes involving exposure to the weather.

LIGHTING RAILWAY CARRIAGES.—The London and North-Western Railway Company have for the last few weeks been making experimental use in one of the carriages of the Irish Limited Mail of a method of lighting devised by Herr Pintsch, a well-known gas engineer, of Berlin. The illuminating agent is gas made by the destructive distillation of shale or other coarse oil. This gas contains more carbon than coal gas, and burns with much less rapidity. The

apparatus for manufacture occupies but little room, and is very simple and inexpensive. The gas, when made, is pumped into an iron reservoir, tinned inside, which is placed underneath the carriage; and the gas is compressed by the pumping into one-sixth of its original volume. From the reservoir a copper tube leads to a small chamber called the regulator, in which the gas expands again, and from which ordinary feeding tubes are carried to the roof lamps. These are of very simple construction, with iron enamelled reflectors, and the gas burner turns out on a hinge to allow the glass to be cleaned. A stopcock on the main feeding-tube allows all the lamps in a carriage to be extinguished at once, and they are lighted from the roof without removal. The flame of the oil gas is small, absolutely steady, and affords so good a light that very small type may be read easily in any part of each compartment. The reservoir holds about eight cubic feet of compressed gas, equivalent to 48 ft. in the natural state, and this quantity is more than sufficient for two journeys from Euston to Holyhead and back. Each carriage, in all its lighting arrangements, is complete in itself and independent of every other, so that there are no connexions to be made or detached in making or breaking up trains. When used on a large scale, as on some of the Continental railways, the gas is compressed by being pumped by a small steam engine into service reservoirs made out of old locomotive boilers, and from these the carriage reservoirs are filled. Experiments have been made with a view to determine the existence of danger in case of collisions or other accidents; and it has been found that when a reservoir is broken by any violence the gas either escapes harmlessly through the rent, or, if ignited, burns out in a few moments without explosion. The inventor claims for the system great economy as well as great convenience; and, as far as mere lighting is concerned, his contrivance seems to leave little to be desired. *Times, July* 21, 1874.

THE METRIC SYSTEM IN OUR WORKSHOPS; WILL ITS VALUE IN PRACTICE BE AN EQUIVALENT FOR THE COST OF ITS INTRODUCTION?[1]

By Coleman Sellers.

IN compliance with the invitation of the General Supervisory Committee, as expressed through your Secretary, that, as an associate member of the American Railway Master Mechanics' Association, I should prepare a paper on some subject relating to the objects for which this association has been organized, I have decided to call your attention to a matter which may before many years be forced upon you, and which you should be prepared to consider with care; I allude to the proposed introduction, by legislative enactment, of the French system of measurement, known as the metric system.

It is not my intention to discuss the subject in all its bearings, for it is a theme requiring more pages of manuscript than I would care to inflict upon you. But I will state in as few words as possible how the proposed change would be likely to affect the workshops of the land. It is now about three-quarters of a century since the mètre was first made the legal standard of length in France, and during that time it has been adopted by other countries, either in full or in part; so that the advocates of its universal adoption claim that the proportion of the population of the globe, already enlisted in its use, numbers 420,000,000. Hence they argue that, for the sake of a uniform metrological system all the world over, England and the United States of America should also adopt it, to the exclusion of our present system of inches, feet, &c.

Many of our leading colleges are making the metric system the method of measurement in all their teaching, with a view to sending their graduates into the world as advocates of what to them seems so perfect a system.

There can be no doubt that it is very desirable to have uniformity, not only in regard to measurements of all kinds, but also in money, as such uniformity would certainly facilitate trade and advance our knowledge of the works of other countries. Those who use the metric system in all scientific matters find it wonderfully well adapted to facilitate calculation. In spite of its long names it is easily understood by persons of moderate education, and can be used even by those who have no idea of the Latin and Greek words from which the names are derived. If the world, as we know it in our arts and trades, was to be made over again, and we were obliged to adhere to ten as the base of our arithmetic, it would doubtless be a good thing in some respects, but very unhandy in more respects, as not admitting of binary division. I have heard it declared by men of high intelligence that its introduction now is retarded only by prejudice, by the unwillingness of people to give up what they are used to, and the necessity of learning certain new rules and methods of thought. Unfortunately, may be, there is something more than these objections that will retard its introduction. The change involves the expenditure of money—of very large sums of money. When this cost is presented to our minds, we may well consider whether the results to be obtained will warrant the expenditure.

The late Senator Sumner was its earnest advocate, and at one time was determined to push the adoption of the metric system. He said to one of our most distinguished scientists, "I am content to have it legalized in 1870 and to have its use then optional, but in 187- I will make its use compulsory." The gentleman to whom he addressed himself, asked if he had well considered what a tax such a measure would impose on the country. "We have now in use," he said, "in all kinds of trades, the pound as our unit of weight, and Messrs. Fairbanks and other scale-makers have for years been making platform scales with beams graduated to pounds. The edict that abolishes the pound will necessitate a change in all these machines for weighing. All their beams must be removed and regraduated to the new unit at an enormous expense." He instanced the change in the weight unit as the one most readily made, as it in the main affects perishable property only.

On February 8th, 1870, a resolution was passed in the United States Senate, that "The President be requested, if not incompatible with the public interests, to invite a correspondence with Great Britain and other foreign powers with a view to promote the adoption, by the legislatures of the several powers, of a common unit and standard of an international gold coinage," &c. In accordance with the spirit of this resolution, a dispatch was prepared by the Department of State.[1] In this paper, after recounting the requirements of such a unification in coinage as shall not prejudicially affect our interests, it says:—

"It is to be observed that an identity in the measures of value in the different countries will not completely attain the beneficent results which are sought, unless there be also an identity in weights and measures. . . . . In commercial transactions an identity in measures of value would be of comparatively little use, if unaccompanied by identity in the measures of the quantities to which those values are applied. There would still be a necessity for the intervention of an expert to shift the expressions of the measures of quantity, from the terms used in one country, to those in use in the other. The resolution of the Senate does not contemplate the extension of this correspondence to these points; nor in my judgment would it be desirable to do so.

It would probably not be difficult to induce the people of different countries to adopt a common standard of weights and measures so far as perishable property is concerned. At first the adoption of unaccustomed systems might cause inconvenience and discontent, but if they should prove to be better than the old ones, and if they should have the further advantage of being common to several countries which possess a common standard of value, and which have extended commercial relations, it is probable that the inconvenience would be patiently submitted to, in view of the greater benefits to be derived from the change.

But it seems to the government of the United States that a forced change in the measures of distance, as applied to imperishable property and the permanent investment of capital, may be attended with more serious inconvenience. Thus while it may be practicable to establish a new standard of length measure for articles of international commerce, such as textile fabrics which are consumed and do not remain, it may be more difficult to make the same change in the standard for permanent values. A few examples will demonstrate the difficulties that would probably attend a change in such measures in this country. . . .

It is the custom in the United States to lay out all towns and cities in regular quadrangles, and to divide each quadrangle into an even number of lots with an even number of feet. This has been found a convenient mode of dealing in town and city houses. To make an arbitrary change, which should abolish these measures and substitute different ones in their places, involving the use of fractional numbers, would occasion great inconvenience, and might check the dealings in these species of

[1] A paper read at the Chicago Meeting of the American Railway Master Mechanics' Association, May, 1874.

[1] See U. S. Report on Foreign Relations for 1870.

property, and cause a loss to those who happened to be holders at the time of the change. Again, the whole system of titles in those states which have been created out of the public domain rests upon government survey, whose results are expressed in the English mile and its subdivisions, rods, feet and inches. To substitute a different measurement would be a work of serious magnitude.

Again, and this is what most seriously affects our interests, the manufactories of the country are filled with machinery, whose delicately adjusted parts, measured in feet, inches and component parts of the inch, work together in one grand whole, which is in its turn combined in the same system of measures. To produce this machinery, thousands of shops are filled with costly plants, adjusted upon the same scale, whose delicate operations often require a nicer determination of measurement than can be obtained without mechanical aid. To transmute these measurements, so delicate and accurate, from the present system into a new one, would appear to be an almost endless labour, if indeed it be a possibility."

To show how clearly these statements express the difficulties that would attend our adoption of the metric system, I will call your attention to certain conditions of the mechanic arts in America, perhaps not fully appreciated by those who think the change is one of education only.

Eli Whitney, whose name has always been associated with the invention of the cotton gin, started in 1798, an establishment for the manufacture of small arms on the principle known as the interchangeable system, carried out by the use of hardened jigs or forms of the same shape as the parts to be produced, thereby making all parts of guns alike and interchangeable one with another. He introduced the use of milling, by means of revolving cutters, those intricate shapes needed in gun work. When he proposed to Thomas Jefferson, then Secretary of State in Washington's Cabinet, to make an arm modelled after the approved French Charville flint-lock, in which all parts of all guns should be interchangeable, he was ridiculed by both French and English ordnance officers. The government aided Mr. Whitney, and in 1800 the present Springfield Armoury was established, and Mr. Whitney's inventions and system put in force there. It was not until 1855 that the English War Department was forced to adopt the same system, importing a large amount of machinery from America for that purpose.

This was not the only branch of the mechanic arts, that was benefited by this interchangeable system. America, contending with high labour, has been forced to exercise ingenuity, and make labour-saving machines produce cheaper work. This could only be done by carrying the interchangeable system into other processes of manufacture; and American clocks, watches, sewing machines, and all the countless small articles of hardware are made by machinery, each piece like the others. Recognizing the absolute need of this interchangeable quality in everything manufactured, but few trades exist in this country that do not avail themselves of its advantages. Gradually, separate and distinct manufacturing establishments have come to use the same standards and to make their production interchange one part with another. Witness the various devices making up what is known as line shafting, as also all the screws and fittings for steam, gas and water pipes, and now the so complete recognition of the American system of screw threads for bolts and nuts. The primary object of this association may almost be said to be to introduce uniformity in all parts of the great railroad system of the United States. There is no country in the world where the value of uniformity in the devices used in common by all mechanics is so fully recognized as in this land of ours. What has been done in this direction, and what is being done now, is founded on the inch as the unit of measurement in the machine shop.

The machine shop, however, is not independent of other trades, and it is necessary to a proper understanding of our subject, that we have a clear perception of the nature of this inter-dependence. Machines made of metal have parts cast and parts forged. Wrought iron is procurable in bars of certain merchantable sizes. When rolling mills are obliged to make round iron, differing in diameter from these merchant sizes, the price per pound is increased, as special appliances and extra care is required. So the mechanical engineer conforms his proportions to the procurable sizes of bar iron, and uses the iron, as far as possible, without the expense of re-forging into other sizes. This is noticeably the case in regard to rounds and squares. The tools and appliances in the machine shop have in time been made to conform to these sizes, and are all expressed by the division of the inch into halves, quarters, eighths and sixteenths. All the gearing in the country, all the patterns of cog-wheels, are spaced in the teeth by pitches measured in inches, and the binary division of the inch, $\frac{1}{4}''$, $\frac{1}{2}''$, $1''$, $1\frac{1}{2}''$, &c. pitch; or, in number of teeth to the inch in diameter, called in practice per-inch wheels, as 12, 10, 8, or 6 per-inch, meaning so many teeth to each inch in diameter; as, for instance, a wheel three inches in diameter cut to ten per-inch, has thirty teeth, *i. e.* $10 \times 3 = 30$. The patterns of gear wheels, in some instances, form no insignificant part of the stock-in-trade of large machine shops, and the immense number of wheels now spaced to pitches in inches must necessitate the continued use of them, whether we call the pitch 1″ or 25·38 mm.

When the metric system was introduced into France, all machine work was done by hand; the planing machines for metals, and all the various appliances known as machine tools, with the exception of the turning lathe, were almost unknown. Sizes expressed in one measurement or another were of less moment than now. I dare say many of my hearers remember the time when the rule of thumb was the mechanic's rule; when the "boss" chalked on the carpenter's bench a thing about "so big," to be made in metal, and then some other thing was made to fit it; at such time it mattered little what standard was used as measure. While French savants were labouring to build up this decimal system of interchangeable measures, the better class of American mechanics were solving the problem of making machinery with interchangeable parts. I am perfectly willing to concede that there are workshops in the land, in which the change from the inch to the metre could be made at very little cost, simply because these shops are furnished with no special devices for measurement even at this day; such drills and mandrils as they may have, are altered in size at the whim and fancy of the workmen. The proprietor of one of this class of shops asked me, not many years ago, if we had a pattern of spur wheel of some pitch and diameter; and when I asked him if he had measured the diameter at pitch line of wheel, he wanted to know what the pitch line meant. Metres would do for that man quite as well as inches. Such machinists, in stating dimensions, use the terms full and scant to express fractions which might be quite readily stated with accuracy; sometimes, however, indulging in the extra expression of a "leetle full scant" for very nice measurement.

A well furnished establishment is provided with gauges, mandrils, reamers, standard drills and boring tools, as well as all other appliances needed for accurate work, made to certain fixed sizes; and in most shops these special tools amount in value to large sums of money. The nomenclature of the sizes of these tools, as expressing the work they are expected to do, is part of their economical use; thus, an inch reamer is expected to make a hole exactly one inch in diameter, and no great effort of memory is needed to designate its size; but this same inch reamer will make a hole 25·38 millimetres in diameter—which is the same size expressed in French measurement.

In the machine shop the unit of measurement is the inch—it is not the foot nor the yard; we express in inches all measurements of objects that may sometimes be made less than 1 ft. in size. Thus pulleys are rated as 5″ or 10″ or 72″ in diameter. Boilers are spoken of as being 36″, 42″ or 48″ diameter. Car wheels are 30″ 32″ or 36″ in diameter. For all calculations in the drawing rooms we use the inch and its decimal divisions, corresponding exactly with our dollar and its divisions into halves, quarters, eighths and sixteens. As in money, we say half a dollar or fifty cents with equal facility, so in measurement we have the half inch or ·50 inch, each as expressive of size as the other.

The advocates of the substitution of the metric system for our favourite inch say we have only to give new names to these sizes. This we can do; we can call our inch 25·38 millimetres, or, if we prefer, we can call it the twenty-five hundred and thirty-eight hundred-thousandths of a metre; or we can call it two centimetres, five millimetres, and thirty-eight hundredths of a millimetre. They say, further, we can make a slight change in our sizes, and dropping the fractions of the millimetre, use the even millimetre; thus our familiar inch would be replaced with the twenty-five millimetre size, which is a decidedly "scant" inch. At the foot of the next page I give a list of all our usual fractions of the inch, and our even inches up to twelve inches, expressed in metric measurement.

Let me now explain how this change of size is to be brought about; that is, what we must do if we are obliged to give up our inch. The drawings of all our machines—drawings that have accumulated through many years, and are expressive of enormous sums of money, and the best mechanical talent of the land—must be gone over, and all the sizes changed. To express in millimetres the present size in inches would never do—it would involve us in a sea of fractions that would drive any ordinary brain crazy. No, we must alter all the sizes to the nearest even millimetres. Thus, some dimensions, marked three inches, must be changed to seventy-six millimetres, ·14 of a millimetre smaller than three inches, and some other size must be altered to make up the loss. Think of the labour involved in such a change, and you will not require me to say what such a change

will cost. But it is said new work can be made to the new sizes, and the old sizes can be continued for the time. This is exactly the point I wish to reach in the statement of trouble and cost involved.

Drawings made twenty-five years ago are in use to-day, and drawings made during each of the succeeding years are many of them in use, and the tools and gauges are perfected to manufacture machines in accordance with these drawings. To-day we begin new drawings with the new dimensions; the change can be readily made in the drawing room. It requires no vast amount of education to substitute one drawing scale for another. We send the new drawing into the machine shop, and then the cost begins; all our old tools of fixed sizes, all our old gauges are wrong; new ones must be made, and we must run the risk of mistakes from the simultaneous use of two standards. Now, for your information, I have taken the trouble to make a careful estimate of the cost involved in altering or making new (for we dare not alter all the taps, dies, reamers, mandrils, gauges, and the other guides for the workmen in an establishment fully equipped for say 250 machinists), and the sum foots up to $27,000—more than $100 for each man employed. This does not contemplate any change in existing drawings; should we attempt to alter all the drawings, I cannot see how, in the same establishment, the change could be made at a less cost than $150,000. What do you think of such a change at such a cost? Would it not indeed paralyze this industry?

President Barnard, in his very able report in favour of the metric system, or rather in favour of some unification of measurement, says: "I do not expect that this system will make its way in the world against the will of the people of the world. I do not expect that our people, and I do not desire that any people, shall be coerced into receiving it by the force of 'imperial edicts,' or by the terror of bayonets. What I do expect is that they will sooner or later welcome it as one of the greatest of social blessings. What I do expect, is that they will one day become conscious of the many inconveniences to which they are subjected, from the anomalous numerical relations which connect, or rather, we might say, disjoin, the several parts of their present absurd system; inconveniences which they have learned to endure without reflecting on their causes, or suspecting that they are unnecessary in the nature of things; and that when fully at length awake to the slavery in which they live, they will burst the shackles, and rejoice in the deliverance which the metric system brings. This cannot take place, of course, until the people are thoroughly informed."

Business men in all times look at the cost of each change. School men see beauties in the metric system, and train their pupils as its earnest advocates, but they do not count the cost. If it is needful to make the change, it can be made more cheaply to-day than to-morrow, more cheaply this year than next. While the schools educate the people to see its advantages, the money value of the permanent plant to be changed is increasing more rapidly than the uninformed on this subject can appreciate. Changes in such things as standards of measurement have been made in other countries, and changes, if needful, can be made now; but the question may in all fairness be asked—is it needful in this instance? So far as my own experience goes, having had the opportunity to use the inch and millimetre in one and the same establishment for many years, using one with as much familiarity as the other, my choice is most decidedly in favour of the inch as the unit of measurement in the machine shops and on the railroads of the country. That others think so too, in regard to one question in mechanics, let me prove by an example. Many years ago, Mr. Whitworth attempted to establish a uniform system of screw threads based on the inch as its unit. His scheme met with such success that now, with the exception of France only, all the metre-using peoples of the world have adopted the Whitworth system, and it has even been largely adopted in this country. It is considered better and more convenient than the French system. According to Mr. Whitworth's system, a half inch screw should have twelve threads to the inch. To express this in the metric language, a bolt 12·7 millimetres should be 2·12 millimetres pitch. I have said business men count the cost before making changes in matters of habit or use, but when they can be shown that they will be gainers by the change, they give in to it heartily. The same example of screw threads will serve as an illustration. Mr. Whitworth's system of screw threads was already introduced in all the principal workshops of Europe, and in many in this country. But a better system was presented to the Franklin Institute, a system based on such simple laws that, given the formula with no existing original to copy, any careful workman can originate a given thread that will match those in use. After an exhaustive debate on the subject of its introduction by the various departments of our Government, and a careful consideration on the part of our mechanical associations, it came to be adopted as the United States standard. It was adopted at considerable expense, because it was believed to be an improvement on existing practice. We have still to keep up our old taps and dies for repair work, but no mechanic has deemed the expenditure involved in the change other than judicious.

To enable you at your leisure to consider the value of our inch unit, as compared with the French system, I have added at the end of this paper a list of some of the prominent metric screw systems, as compared with the United States standard and the Whitworth.

Recognizing the advantages offered by the decimal system in money, we accept the dollar and cents in preference to the pound sterling of England. We now have in use, in land-surveying in the country, the chain and its decimal division. In city measurements, the foot and its decimal division is also used; and in mechanics, we have the inch as our unit, with its division into one-hundredths for calculation, and into vulgar fractions, where its written expression is rendered plainer thereby. I have

RELATIONS OF THE METRE AND THE INCH.

Millimetres.	Inch.	Inch.	Millimetres.	Millimetres.	Inch.	Inch.	Millimetres.	Inches.	Millimetres.
1	·03937	1/16	1·58	13	·51182			2	50·76
2	·07874			14	·5512	9/16	14·26	3	76·14
3	·11811	1/8	3·17	15	·59056	5/8	15·85	4	101·52
4	·15748	3/16	4·73	16	·62994			5	126·9
5	·19685			17	·66931	11/16	17·43	6	152·28
6	·23622	1/4	6·34	18	·70868			7	177·66
7	·2756	5/16	7·92	19	·74805	3/4	19·02	8	203·44
8	·31497			20	·78742	13/16	20·60	9	228·42
9	·35434	3/8	9·51	21	·82679			10	253·80
10	·39371			22	·86616	7/8	22·19	11	279·18
11	·43308	7/16	11·09	23	·90553	15/16	23·77	12	304·56
12	·47245	1/2	12·68	24	·9449				
				25	·98424	1	25·38		

Centimetres.	Metre.	Inches.
1	·01	·39371
2	·02	·78742
3	·03	1·18113
4	·04	1·5748
5	·05	1·9685
6	·06	2·3622
7	·07	2·756
8	·08	3·1497
9	·09	3·5434

Decimetre.	Metre.	Inches.
1	·1	3·9371
2	·2	7·8742
3	·3	11·8113
4	·4	15·7484
5	·5	19·6855
6	·6	23·6226
7	·7	27·5596
8	·8	31·4976
9	·9	35·4339

1 metre = 39·371 in.

in this paper made no attempt to discuss the merits of the metric system as carried out in all its perfection, through measures of distance, surface, solidity and weight. This has been considered by abler men than I am. My object has been to present to you the cost involved in the change, and to show that something more than want of education strengthens the hands of Englishmen and Americans in resisting any change in their methods of measurement. By the law of our land, those of our citizens who choose to use the metric system can do so, and their so doing will meet all requirements of the law; but the standard of the land is, for our purposes, the inch, and I for one should be sorry to see it abolished.

If, as I am informed, some of our schools of science see fit to make their method of teaching dependent on the metre and its divisions, to the exclusion of the ordinary nomenclature of the land, their wisdom may well be questioned. We need educated engineers, but we need them educated in our mode of thought. The universities of the land are awake to the need of scientific education, and our sons are sent to them that they may learn what will be of the most use to them in active life. We wish them to learn the languages of other leading lands, but we insist that they shall know their own language. We would have them read the scientific languages also, but if for good reasons we choose to retain our technicalities, deeming them more convenient for our use, we also insist that they shall know how to use them in our business relations.

Impressed as I am with the insurmountable difficulties in the way of a change in our unit of measurement, even if that change was desirable, I cannot help thinking that, if the hypothetical New Zealander, when he has done contemplating the ruins of St. Paul's, from the sole remaining vestige of London Bridge, in the far-off distance of the future, shall seek from the ruins of a mighty city to learn the nature of a nation's greatness, and shall measure its length and its breadth, as did Prof. Piazzi-Smyth the Pyramids, he will find its unit of measurement to have been the inch.

COMPARISON OF SCREW THREADS IN USE.

FRANCE.								ENGLAND.				AMERICA.			
	Pitch in millimetres.							Whitworth.				U. S. Standard.			
Diam. in millimetres	French Railroads.	Denis Poulot.	Bodmer.	Vignole d'Armengaud.		Ducommun.		Diam. in inches.	Diam. in millimetres.	Pitch in millimetres.	No. of threads per inch.	Diam. in inches.	Diam. in millimetres.	Pitch in millimetres.	No. of threads per inch.
				Diam.	Pitch.	Diam.	Pitch.								
3	—	—	0·5	—	—	3	0·5	—	—	—	—	—	—	—	—
4	—	—	0·5	—	—	4	0·75	—	—	—	—	—	—	—	—
5	—	—	0·83	5	1·4	5	0·75	3/16	4·7	1·058	24	—	—	—	—
6	—	—	0·83	—	—	6	1	1/4	6·4	1·270	20	1/4	6·4	1·270	20
7	—	1·50	1·00	—	—	7	1·25	—	—	—	—	—	—	—	—
8	1·50	1·50	1·00	7·5	1·6	8	1·25	5/16	7·9	1·410	18	5/16	7·9	1·410	18
9	—	1·50	1·25	—	—	9	1·5	—	—	—	—	—	—	—	—
10	1·50	1·50	1·25	10	1·8	10	1·5	3/8	9·5	1·585	16	3/8	9·5	1·585	16
12	1·50	1·75	1·47	—	—	12	1·75	7/16	11·1	1·815	14	7/16	11·1	1·815	14
14	—	1·75	1·73	12·5	2·0	—	—	1/2	12·7	2·120	12	1/2	12·7	1·95	13
15	2·00	2·00	1·73	15	2·2	15	2	5/8	15·9	2·309	11	9/16	14·26	2·120	12
18	2·00	2·00	2·00	17·5	2·4	18	2·5	—	—	—	—	5/8	15·6	2·309	11
20	2·00	2·50	2·50	20	2·6	20	2·5	3/4	19·1	2·54	10	3/4	19·1	2·54	10
23	2·50	2·50	—	22·5	2·8	23	3·0	7/8	22·2	2·820	9	7/8	22·2	2·820	9
24	—	—	2·78	—	—	—	—	—	—	—	—	—	—	—	—
25	3·00	3·00	—	25	3·00	25	3·0	1	25·4	3·175	8	1	25·4	3·175	8
26	—	—	2·78	—	—	—	—	—	—	—	—	—	—	—	—
28	3·00	3·00	3·125	—	—	28	3	1 1/8	28·6	3·629	7	1 1/8	28·6	3·629	7
30	3·00	3·50	3·125	30	3·4	30	3·5	—	—	—	—	—	—	—	—
32	3·00	3·50	3·58	—	—	32	3·5	1 1/4	31·8	3·629	7	1 1/4	31·8	3·629	7
34	—	—	3·58	—	—	—	—	—	—	—	—	—	—	—	—
35	3·50	4·00	—	35	3·8	35	4	1 3/8	34·9	4·225	6	1 3/8	34·9	4·225	6
37	—	—	—	—	—	37	4	—	—	—	—	—	—	—	—
38	3·50	4·00	4·18	—	—	—	—	1 1/2	38·1	4·225	6	1 1/2	38·1	4·225	6
40	4·00	4·50	—	40	4·2	40	4	—	—	—	—	—	—	—	—
42	—	—	4·18	—	—	42	4·5	1 5/8	41·3	5·080	5	1 5/8	41·3	4·61	5 1/2
45	—	—	—	45	4·6	45	4·5	1 3/4	44·5	5·080	5	1 3/4	44·5	5·08	5
46	—	—	5·00	—	—	—	—	—	—	—	—	—	—	—	—
47	—	—	—	—	—	47	5	1 7/8	47·6	5·650	4 1/2	1 7/8	47·6	5·08	5
50	—	—	5·00	50	5	50	5	2	50·8	5·650	4 1/2	2	50·8	5·650	4 1/2

GUM Euphorbium.—J. Collins. (*Pharm. Journ.* 3rd series, ii. 1049.) Dr. E. Cosson, in an interesting note on *Euphorbia resinifera*, Berg., read before the Royal Botanical Society of Belgium, verifies the statement of Berg, that the gum euphorbium of commerce belongs to the species to which Berg gave the name of *E. resinifera*. Dr. Cosson found in Von Martius' collection at Brussels, a specimen of gum euphorbium with sufficient of the dried stems of the plant producing it to give a good idea of the plant. Probably Von Martius received these specimens from his brother, Dr. T. W. C. Martius.

The history of this acrid gum is very interesting. *E. canariensis*, L., *E. officinarum*, L., *E. antiquorum*, L., *E. tetragona*, Haw., have each been accredited with its production; but Dr. Pereira, who examined the question with his usual critical ability, stated that only *E. canariensis* fulfilled all the requisite conditions of locality, etc.; and that he felt little hesitation in ascribing the gum to this plant. He says (Elements Mat. Med., vol. ii., pt. l., p. 389, 1855), that the specific characters "apply to the branches found mixed with the euphorbium of commerce. They agree with the description and figure of *Tithymalus aizoides lactifluus*, the *Euphorbia canariensis* of Plunkenet." Miller also (Gard. Dict., vol. i. art. Euphorbium) states that in looking over some euphorbium in a shop, he "found several spines amongst it, which exactly agreed with those of that plant." Pereira found in some specimens of the gum, spines resembling those of *E. tetragona*, Haw.

But better materials led Berg to trace its origin to a new species to which he gave the name of *E. resinifera*, and described from dry remains picked out of the gum. *E. resinifera* has a stem one-third the size of that of *E. canariensis*, and stalked umbels, whilst *E. canariensis* has almost sessile flowers. *E. resinifera* has been figured by Berg and Schmidt in their work on the botany of the Prussian Pharmacopœia. The gum contains 20 per cent of an acrid principle, euphorbin (C_{36} H_{22} O_2), so acrid indeed that in the collection of the gum the fingers become excoriated if brought into contact with it, and it is the practice to cover the mouth and nostrils to avoid the excessive

sneezing which would otherwise ensue. The best general account of the production of this gum, is that of Jackson, in his "Account of Morocco."

Dr. Cosson has also compared the various materials he has with a growing plant at Kew (which has not yet flowered), sent by Mr. F. Cartensen, the English consul at Mogadore. If the history of this plant can be satisfactorily attested as being the species actually producing the gum, its flowering will be looked to with some degree of interest, as the question can then be set completely at rest.

THE METALLURGY OF THE FUTURE.[1]

SINCE it is to you, my colleagues, that I owe the privilege of speaking here to-day, I trust you will permit me to ask your attention to the special branch of our profession to which I have devoted my energies, and, while attempting to bring before you some ideas upon what I shall call the metallurgy of the future, to show you what a fruitful field of study the iron industry can furnish, not only to those of our number who are connected actively with metallurgical operations, and have consequently at their command every opportunity for observation and experiment, but also to our Parisian brethren, who, though confined to researches more theoretical in their character, may yet be willing to consecrate to their investigation a portion of their time. I hope you will prove how easy it is to enrich our journals with original papers of great interest, and at the same time to render a service to a most important industry.

My purpose on this occasion, however, is not to occupy the time with a statement of the part which chemical science at present plays in the progress of metallurgy; a part certain to be largely increased in importance. Nor would I, even if I could, lessen this importance in the least. But it is of course desirable for us not to confine ourselves too entirely to a study of the purely chemical questions involved; for chemistry alone will certainly not be able to reach the solution of many problems which are even now actually occupying the attention of metallurgists. To solve these questions physical and mechanical knowledge is also necessary; and it is rather in this direction than in the other that I desire to lead your thoughts for the hour.

We all, probably, have observed the significant fact, that the more the metallurgical arts progress—and we have witnessed during the past few years some marvellous advances—the more the science of heat becomes of importance in their operations. Indeed, we might almost say that the metallurgy of the future consists in largest measure in the development of this science. So that for him who will thus develop it, who will produce and control high temperatures, there seems to be in abundance both honour and profit. Even now we see about us many efforts in this direction. A never-ceasing duel is being fought between fire, whose most violent energies are roused for the combat, on the one side, and the refractory material which is to contain and to control it upon the other. This duel recalls forcibly another contest also waged in the metallurgical arena—because in fact it is the industrial art which is really involved, not the military art—the strife between artillery and plating, between large guns and iron-clads. To construct large guns, to make them support the colossal interior pressures which correspond to the great initial velocities obtained, and which give to heavy projectiles the enormous *vis viva* which shall crush in the sides of the heaviest iron-clad before their terrible impact, taxes the profoundest resources of the metallurgist and the mechanical engineer. To manufacture plates, on the other hand, thirty, forty or even fifty centimetres thick, designed to sustain without yielding these frightful blows, to resist them without being either penetrated or even fissured, demands the most advanced skill in the iron master and at the rolls. In this Homeric duel, which has already taken on so many phases, the superiority at present is on the side of the attack. The projectile has finally triumphed over the armour. It now seems as if the result would be the same in the case of the other duel, between fire and refractory material.

Moreover—to return from our digression—how immensely inferior are the temperatures which we are actually able to obtain, to the fantastic figures which we so often have from the mouths or pens of enthusiastic inventors. Many practical men, even, are singularly in error in regard to the means in their possession for developing high temperatures. This is a subject which has not yet been sufficiently studied, in my opinion, in the light of modern science; or, if studied, the results have not been widely enough disseminated. I ask your permission, therefore, to point out the way in which, as it seems to me, we should study this question; and, as a preliminary thereto, to give a rapid résumé of the present condition of it in actual practice.

The great majority of the metallurgical appliances where heat is generated and utilized, belong to two great classes—blast, or high furnaces, and air, or reverberatory furnaces. The former class, including both high and low blast furnaces, are among the oldest metallurgical appliances known; iron, lead, copper and tin were at one time produced exclusively in blast furnaces. Now, however, the reverberatory furnace has dethroned the low hearth and the low blast furnace, for the refining of cast iron, as it has for the manufacture of copper. Recently, in the invention of the Bessemer process, the blast furnace has seemed to take its revenge; but very soon after, thanks to the genius of Siemens, the reverberatory furnace regained the lost ground in siderurgic manufacture. And now, as a matter of fact, the Bessemer converter, fed with compressed air, and the Siemens-Martin reverberatory furnace, heated by gas and using the natural draught, divide between them, or rather yield to each other mutual assistance, in the modern industry of steel. These two methods may be regarded as the two types to which we may refer all the possible means of obtaining high temperatures, whether now known to us or hereafter to be discovered.

The more we examine the remarkable invention of Bessemer, the more we are struck with the manner in which it sprang fully armed, so to speak, from the head of its fortunate inventor. From the time of the reading, in 1856, at the Cheltenham meeting of the British Association, of the celebrated paper bearing the title "On the Manufacture of Steēl and Iron Without Fuel," an entirely novel idea took possession of the metallurgical world; an idea, too, destined to be still more fruitful in results in the near future. The heating of the metal in the converter is effected without the aid of any foreign combustible substance, solely by the intermolecular combustion of the constituents of the cast iron; this combustion being effected under a pressure considerably superior to that of the atmosphere. In this way, the utilization of the heat thus produced within the metal itself, is direct and immediate. Most of it is actually absorbed by the metal, leaving but a small residue to be taken up by the walls of the converter.

The system of heating made use of by the Siemens Brothers, in their furnaces, is entirely different. Here the heating is effected by means of combustible gases, produced by the distillation and imperfect combustion of coal. Their reverberatory furnaces possess two heaters, one at each end, each consisting of a sort of elongated rectangular burner, with two parallel openings, one for air, the other for the gas. Both the entering air and gas are separately heated to a very high temperature. When they meet, under a pressure about that of the atmosphere, they combine and yield a powerful flame, which traverses first the furnace, where it heats the metal, and then passes through chambers filled with loosely laid fire-bricks, called regenerators. Here it gives up a large part of its remaining heat, which is to be utilized a few minutes later, in the next stage of the process, in heating the entering air and gas before their combustion. The metal forms a not very thick layer on the bed of the furnace, and is heated only by the superficial contact of the current of burning gas, and by reflection and radiation from the furnace walls, these latter being heated in advance of the metal, so that it becomes necessary frequently to cool them by artificial means (either a current of air or water) to enable them to stand the heat. The temperature of the metal on the Siemens hearth is lower than that in the Bessemer converter.

The temperature which may be obtained in a gas furnace on the Siemens system, or in the furnaces of other and more or less analogous systems which have appeared within the past few years, cannot exceed a certain maximum, which I have made some attempts to determine. The researches of Deville and Debray have proved that when we bring together, in the proportions to form water, the two gases oxygen and hydrogen, at the ordinary atmospheric pressure, all necessary precautions being taken that no part of the heat produced be absorbed by the surrounding materials, but that it be entirely confined within the products of combustion, the actual maximum temperature which is obtainable is only 2500° C., in place of 6903°, which Peclet had deduced from calculation. The discrepancy in the theoretical and experimental results is easily explained, if we remember that only one-half of the hydrogen enters into combination at 2500° under the ordinary atmospheric pressure, the vapour of the water produced having at this temperature a tendency to decompose precisely equivalent to the affinity which, at this temperature, oxygen and hydrogen have for each other. Or, in more scientific language, at 2500° the tension of dissociation

[1] An Address delivered before the Society of Civil Engineers of France, by their President, M. Jordan.

of the vapour of water is equal to the atmospheric pressure. Whatever, then, be the initial temperature of the two gases when they are mixed, we can never obtain by their combination a temperature of combustion superior to 2520° (or 2800° according to Bunsen). If the oxygen be mixed with an inert gas like nitrogen, the relative proportion of hydrogen actually entering into combination may be increased, but the actual temperature of combustion cannot be raised above this limit. But if the combustion be effected at higher pressures, at two, three, or even more atmospheres, experiment shows that the quantity of gas entering into combination goes on increasing, and that the temperature of combustion increases in the direct ratio of the pressure. Under the ordinary pressure of the atmosphere, however, the fact remains that the maximum temperature which can be produced by the combustion of pure hydrogen, a maximum impossible to attain in practice, is only about 2500° C.

The temperature of total combustion for carbonic oxide and oxygen, as determined by calculation, is 7059°, according to Peclet. But the tension of dissociation of the carbonic acid produced is considerable even at 1200°, according to Deville. Hence, although the temperature at which this tension is equal to the atmospheric pressure, that is, the temperature at which carbonic oxide and oxygen can no longer combine, has not, as far as I know, been experimentally determined; it must be certainly very far below 7000°, and probably even below 3500°.

The presence of nitrogen, when the combustion is produced by means of air, diminishes still more the temperature obtainable. Consequently, notwithstanding the great respect in which I hold the name of Faraday, I am constrained to doubt if it be possible, as Siemens tells us he said, in 1862, it would be, to obtain a temperature of 3850° C. in a furnace heated by the combustion, effected by means of air, and at the ordinary pressure, of a gas containing itself more than two-thirds of inert material.

Moreover, it is necessary also to remark, that in the Siemens furnace the metallic bath absorbs only a small proportion—15 to 20 per cent.—of the heat produced by the combustion; the rest being expended upon the furnace itself, in heating its walls and its regenerators, and in loss by the stack. Obviously a flame, the weight and calorific capacity of which are so feeble, and which is in contact with a surface of brick so much more extended than that of the molten metal, cannot furnish rapidly enough a sufficient number of heat-units to raise the temperature of the furnace and the metallic bath up to that which it itself possesses, especially when the loss by conduction is taken into the account.

According to a Belgian engineer (M. Kranz), who has analysed the working of the Siemens furnace with great care, the mean temperature of the flame on its entrance into the furnace is 3023°, that of the interior of the furnace itself being 1800°. But he does not take into account the dissociation of the carbonic acid produced, which at this temperature must be very considerable.

It is no doubt very difficult to measure in degrees the highest temperatures which can be obtained in the Siemens furnaces which are employed for melting low steel, though their inventor has undertaken to do this by means of his electric pyrometer. I believe, however, that I risk nothing in asserting that the figures of Kranz above given may be considered as a maximum.

In the Bessemer converter, owing to the small size of the opening by which the gases escape, the interior pressure is always very considerable, sometimes exceeding even by one-half the atmospheric pressure. Moreover, the carbon of the iron is burned only to carbonic oxide, which dissociates much less easily at high temperatures than carbonic acid. The silica, too, resulting from the combustion of the silicon, does not decompose at all, but remains in the liquid state in contact with the metal. For all these reasons, the temperature obtained in the converter is superior to that obtained in the Siemens furnace; this temperature may be safely estimated as 3500°.

Mr. Bessemer himself understands fully the importance of effecting the combustion under a high pressure. In realization of this idea, he has quite lately, in 1869, invented a special apparatus for the purpose, a sort of hermetically closed converter, into which he blows air under a pressure of two to two and a-half atmospheres, and out of which the gaseous products of combustion issue through a very small opening, the size of which can be adjusted at pleasure. In this way he has succeeded in melting the softest iron easily, and with only a small quantity of fuel. But the direct contact of the carbon has prevented him from obtaining the melted metal sufficiently soft, a slight amount of carburization always taking place. For this reason Bessemer has abandoned this first apparatus for another, in which the combustible does not come in contact with the melted metal. It is a sort of hermetically sealed reverberatory furnace. I am not aware in what condition these experiments are at present, nor do I know of what materials these high-pressure furnaces are constructed. But I see in all this a new proof of the originality of mind of this distinguished inventor.

What has thus far been said will be sufficient, I trust, to justify now the enunciation of the following propositions, which embody, as I conceive, the conditions necessary for the production of temperatures still more elevated than those which are at present actually in use. These propositions are—

1st. The combustible which is selected to be used as fuel must be capable of being burned within the molten metal without injury to the properties of this metal, and must yield on combustion a non-volatile product.

2nd. An arrangement of furnace must be devised, heated by gas or otherwise, in which practical operations can be carried on under a pressure of several atmospheres.

It is impossible for us at present to foresee the changes which would be effected in metallurgical processes and results by the employment of temperatures more elevated than those we now actually make use of. A distinguished English physicist, J. Norman Lockyer, in a communication read to the Institute the other day by M. Dumas, states that during his spectroscopic investigations he has recognized the important fact, that in those stars which are hottest, only pure hydrogen is to be detected; that in those which are less hot, the metals make their appearance; in others yet lower in temperature, the metalloids appear; while, finally, here upon our earth, which is only an extinct star, hydrogen no longer exists free, and but a few metals and metalloids are found in this condition; while we do find an immense number of compounds of all degrees and kinds of complexity. It is easy to see from this statement of Mr. Lockyer that he considers hydrogen gas to be the ultimate limit of all dissociation; to be what Balzac, in a recent and well-known novel, calls the "absolute," and what others have called "cosmic matter." Hence he must believe that all bodies are simply metamorphoses or transformations of hydrogen, due to variable circumstances of pressure, temperature and electric state. It is hardly probable, however, that we shall ever see the number of our elements reduced to one. But shall we ever be able to carry dissociation to a degree sufficient to separate even recognized elements from each other? to dissociate, for example, iron and oxygen, or iron and phosphorus? It must be confessed that nothing that we know as yet permits us to hope for it. But, precisely as the Bessemer and Siemens-Martin methods have given us cast steel in enormous masses, so methods may be devised, still more energetic, which shall enable us to obtain this and other metals in molecular states which are now unknown. Let me detain you a few moments upon this point.

The science of molecular mechanics is yet in its infancy, and for this very reason it presents a rich field for investigation and experiment. We are already acquainted with iron, for example, in very many physical conditions. We have learned within a few years how to obtain it melted like steel and cast-iron. But how numerous are the things which yet remain for us to learn, in order to understand the properties of even these various states of iron; in order to explain the peculiarities which they present when viewed from the standpoint of construction; in order to establish the relation which should subsist between these different molecular states, and the resistance of the metal under various strains; in order to have as definite a theory for working iron cold as for working it hot. This knowledge, which may be called the physics and the molecular mechanics of iron, is still very rudimentary. We have in our own ranks—and we may be proud of him—a learned engineer who was among the first to devote himself to the ascertaining of this knowledge. His researches upon the flowing of solids and upon the forging of metals are destined to bear him rich fruit, especially in connection with the parallel series of experiments upon the resistances and the deformations of metals, which he has published with them. Will he permit me to express a regret that he has not decided to communicate to the engineering profession, through the agency of our own organisation perhaps, the valuable data already in his possession, which would form so exceedingly valuable a basis for future investigations of the same sort?

Availing myself of this opportunity, I will attempt to lay before you a sketch of what I foresee in these molecular studies, at present unfortunately too much neglected. I will enter upon the subject through a phenomenon well known to every one. It is a matter of common knowledge that iron is capable of being welded; that if two pieces of iron be heated to a temperature, called for this very reason a welding heat, and then be pressed together, either by hammering or by energetic pressure, the two pieces will be firmly united, *i.e.*, welded together. Why is this? The only explanation which we can find in the best works on chemistry or metallurgy is the following:—"At a white heat, iron acquires the property of being welded, a property which it shares with the metal platinum only." But obviously there is no evidence here of any mysterious and special property of iron called weldability; there is only the effect of a very general

cause, the manifestation of a molecular property elsewhere abundantly active in nature.

Take two pieces of ice, at a temperature just below zero, press them even very gently together, they become at once welded to each other. This is the phenomenon, first observed by Faraday, and subsequently investigated in so fascinating a way by Thomson and Tyndall, which has received the name "regelation." Thomson explains it in the following manner:—For all bodies, like water, which have the property of diminishing in volume as they liquefy, pressure, which tends to bring the molecules closer together, lowers the temperature of fusion. Consequently, when two pieces of ice are rubbed against each other, fusion takes place between the surfaces of contact, at a temperature below zero. Of course, as soon as the pressure ceases, solidification is again produced, and the pieces are welded together.

It seems to me that the welding of iron is a phenomenon exactly similar to regelation. The two pieces of iron are brought to a white heat, that is to say, more or less near to the fusing point. The repeated blows of the hammer, or the pressure of the rolls, lowers the point of fusion, and causes a superficial liquefaction of the parts in contact, and thus welds the masses together; and this because, like water, iron dilates in passing from the liquid to the solid state. Many other metals are similarly endowed; they all, therefore, may be welded like iron, if other conditions do not come in to oppose the manifestation of this property. Platinum welds easily at a white heat, because its non-oxidisable surface, like that of ice, takes on a superficial fusion. To weld iron successfully, it is necessary that its surface should be clean, that is, free from oxide. Iron containing phosphorus welds more easily than pure iron, because its point of fusion is lower. Steel, which is more fusible still, welds at a lower temperature than iron, but the process is a more delicate one. Silver, too, like iron and platinum, has the property of expanding when it solidifies; but as it melts at a cherry red heat, it is easier to form it by casting than by welding. Bismuth and zinc are also included in the same class; but they are so very brittle near their fusing points that no one would think of attempting to weld them either by hammering or pressure.

Iron, in welding, therefore, only follows the example of water. The careful comparative study of these two bodies, even though at first sight apparently so dissimilar, cannot fail to furnish, for this reason, results of great interest to the metallurgist. I have lately read an excellent book by Mr. Tyndall, upon glaciers and the transformations of water, and I have been repeatedly struck with the great number of analogies presented by these two bodies. Indeed, I might almost say similitude, were not the fusing points of the two distant from each other more than fifteen hundred degrees Centigrade.

When snow is at a temperature not too far below zero, children amuse themselves by making balls of this substance and increasing their size by rolling them upon the white layer beneath, the simple weight of the primitive ball being sufficient to cause the agglomeration of the successive layers. If a snowball be compressed in the hands a hard mass is obtained, which is at first white and opaque; if the pressure be increased, a translucent mass results, and if it be very considerable, a piece of transparent ice is produced, care of course being taken to expel the traces of air entangled mechanically between the snow crystals.

Place fragments of ice, coarsely broken, in a mould furnished with a cover, and compress them energetically, either by the blows of a hammer or by means of a press, and you will obtain, if the temperature of the mass be near 0°, a compact block, which takes the exact form of the mould. Having moulds for roughing the block out and others for finishing it, you may stamp the ice so as finally to form an object of almost any desired form. In one of his celebrated lectures on heat, Mr. Tyndall made in this way a cable-link in the form of the figure eight. Pounded ice regelates better than snow, and therefore permits better the repetition of this last curious experiment. But even a snowball well compressed may be converted into the form of an elongated solid; and then, operating with care and slowly, one may, either by pressure or by a succession of slight blows, form it gradually into an ice-block of any desired form.

Now in what does all this differ from the work performed by the puddler when he forms his ball in the furnace by rolling together the crystals of iron which have come to nature there in the midst of the slag? when in shingling, the expulsion of the liquid scoria from between the crystals of iron is effected, either by pressure or by a blow, either under the hammer or within the squeezers? A piece of iron forged at a bright red heat seems to act like a viscous body; it becomes extended in various directions, and, in fact, acts like the ice of a glacier, which flows along its bed, conforming itself to all its sinuosities. But the ice of a glacier is not viscous; it has been shown that this appearance is due to the continual formation of innumerable cracks, the surfaces being immediately united again by regelation, under the pressure of the superincumbent masses.

Even if iron can be forged at a red heat, we know that at this temperature it will not support severe traction. Iron wire, for example, cannot be passed through a draw plate at a high temperature, its resistance to traction being then too feeble. So it is with ice; if it can support a pressure, it cannot stand a tensional strain, but breaks without sensibly elongating.

Physicists, like Tyndall and Helmholtz, distinguish two kinds of ice; lake ice, which is formed by a regular crystallization on the surface of still water; and glacier ice, or compression ice, produced either from snow crystals or ice fragments, united into a single block by the effect of regelation. These two kinds of ice act very differently under the influence of an energetic compression. The former, or the crystalline ice, breaks through its mass into a great number of fragments; the latter, the amorphous or granular ice, changes its form and moulds itself anew, by a series of minute crackings scarcely to be perceived. So attempt to forge, without care, an ingot of iron or of steel, and you will cause it to crumble, because it is crystalline; but if you submit this ingot first to the operation of sweating—that is to say, if you heat it to the welding temperature and then, by an energetic pressure, you effect by regelation the welding together of the various crystals of the metal, you will then have a mass which can be forged without difficulty. Even the fragments of such a mass can be welded, although pieces of the primitive ingot are not weldable directly.

Iron made in the puddling furnace is crystalline. It becomes amorphous in the process of shingling and rolling. Steel cast at a temperature near its point of fusion and slowly cooled, is also crystalline in the same way and for the same reason as lake ice. I do not suppose it is necessary for me to say here that water and steel do not crystallize in the same system, nor to recall the fact that carbon and iron are isomorphous.

Again, both iron and cast steel, even after forging, by which all the cleavages have been welded together and the crystalline structure entirely destroyed, may crystallize anew under very many conditions. I have recently seen a section of a steel cannon which was forgotten in the reheating furnace. When it was discovered and removed, it was only a friable agglomeration of small, but well characterized, crystals. So no doubt a piece of compressed ice, maintained for a long time in a confined atmosphere, so as to prevent evaporation, and passing constantly to and fro in temperature, from 0° to —10°, would become crystalline and cleavable. I do not know if the experiment has ever been made, but it would certainly be worth the trouble.

Let me, just here, ask you to note how closely the point which Helmholtz maintained against Tyndall—relative to the innumerable crackings produced in ice by pressure, which permits the moulding of granular compressed ice into any shape, and hence allows it to flow through an opening, like a vein of liquid or like a wire, under the influence of hydraulic pressure, as Helmholtz in a recent lecture has experimentally shown; how closely the point which he makes, that the flowing of solid ice is simply the flowing of an infinite number of minute polyhedrons —resembles the theory which has been quite lately advanced by M. Tresca, concerning the laws of the flowing of solid bodies generally.

Thus far I have said nothing of fibrous iron, because the fibrous state of iron is not a normal and regular one. All crystalline iron, if the crystals are not too hard, breaks with a fibrous structure, if time be given in the breaking for these crystals to be drawn out into fibres. Iron which is fibrous is only iron in which the primitive crystals, surrounded by very thin films of slag, and thus separated from each other, have not been welded together during the rolling, but have been elongated into wires. A bar of such iron resembles a bundle of wires in its resistance to traction, but it breaks with a granular fracture when exposed to a transverse blow suddenly applied.

In considering these two states of iron, the crystalline and the amorphous, we are unavoidably brought face to face with the question, what takes place when the metal passes from one of these states into the other? The experiments of MM. Favre and Silbermann, and of M. Ditte, have shown that bodies in crystallizing disengage heat; and, on the contrary, that they absorb heat in passing from the crystalline into the amorphous condition. This latter condition seems, therefore, to be an intermediate one between the crystalline state, which is a true solid form, and the state of a liquid. The amorphous state is consequently a dynamic state, as I have seen it somewhere defined; a state of more or less unstable equilibrium. Has the crystalline iron which issues from the puddling furnace, and which we transform into amorphous iron by shingling and welding, absorbed any heat? Has it rendered latent any portion of the heat yielded by the fire or developed under the hammer? Are

the specific heats of crystalline and of forged iron, at the same temperature, the same? Both these questions, interesting as they are to the theory of iron making, are yet without an answer.

Moreover, may not the heat which has thus been absorbed, being disengaged again under conditions at present but little known, become an active agent in returning the iron to its original crystalline condition, thus explaining those changes of structure hitherto attributed vaguely to great cold, to continued vibration, etc.? I have seen a bar of good charcoal iron from Franche Comté, left accidentally for some weeks in the welding furnace, and having hence been subjected to intense heatings followed by extremely slow coolings; it had taken on a structure completely and largely crystalline, and yet had lost none of its original softness. Large forgings, such as armour plates, which have to be returned many times to the reheating furnace, and which, after each heating, cool very slowly under the repeated blows of the hammer, exhibit a strong tendency to crystallize in those central portions which are not reached by the blow. In fact these plates do often crystallize at the centre. In order to remedy this condition of things, which constitutes a serious defect, since fracture takes place readily through these cleavages, it is necessary after the plate is entirely finished, not to allow it to cool to the centre, but to place it again in the fire until the exterior has become red hot. It is then plunged into water, which for small articles must be hot, but is cold for large ones like armour plates. In this way the iron recovers its former strength. Without this precaution a plating of good soft-iron would break under the blow of a projectile, with large crystalline facets, instead of resisting its impact. This hardening of masses of iron, which is a device now extensively practised, does not succeed unless the iron be very soft. It is necessary too that the iron should not be hard from the presence in it either of carbon or of phosphorus. The rapid cooling of amorphous iron of a good quality appears to prevent the formation of crystals; very slow cooling, on the other hand, seems to have the contrary effect.

One step more. If in place of considering water and iron in the solid state we compare them in the liquid condition, we find here, too, many curious facts well worthy of investigation. We know, for instance, that water may be cooled, even to 12°, without ceasing to retain its liquid form, if it be left in absolute quiet, and protected from the air. We also know that when in this condition vibrations of any sort, such as would be caused by drawing a bow across the edge of the vessel which contains it, or the contact of a small bit of ice, suffices to determine the solidification at once. The point at which ice melts is therefore fixed; the point at which water solidifies is not; water may solidify at a number of temperatures. It passes into the solid state, however, when it does congeal, as much more rapidly as the temperature is inferior to the fusing point, disengaging therefore, in the process, an amount of heat proportionately greater. When the solidification takes place thus rapidly the molecules have not time to take their positions of stable equilibrium, and crystallization cannot operate. Now have these phenomena of aqueous surfusion anything analogous in the case of molten iron? Would not this be the proper place for some curious comparisons with what we observe in the casting of iron and steel? The temperature at which steel solidifies has certainly considerable influence upon its grain. We recall here, too, the practice commonly employed with certain steels, of closing hermetically at once the ingot moulds, as soon as they have received the metal, and then abandoning them to rest until the solidification is complete. We know, too, that when the steel solidifies in a mould which is in motion, the structure is more massive and less crystalline than when the mould is at rest.

I have now reached the end of my long address. You will pardon me, I trust, for having made it rather a lecture than an opening discourse upon principles and methods. Permit me, in closing, to reiterate the assertion that there are many points in the molecular states of iron which will richly repay the attention not only of men of science, accustomed to the most delicate researches, but also of those practical men, who, as engineers, are engaged in the manufacture or the utilization of this metal. I shall deem myself most fortunate if my feeble voice shall induce even a single physicist to undertake the investigation of some of the problems which suggest themselves in practice; problems, our ignorance of the solution of which prevents progress in all those directions, at least, where it is absolutely necessary to have, as a guiding thread, a sound theory built upon experience.

GAS COOKING APPARATUS.

WE recently received from Messrs. Sidney, Leoni, and Co., gas engineers, of 19, Great George Street, Westminster, particulars of their patent gas apparatus for cooking or heating; and we cannot do better than quote the pith of the patentees' own specification of the contrivance—

"To obtain the maximum of heat with the minimum of gas, I use atmospheric gas; introducing 35 to 40 parts of air to every 100 parts of gas; the gas apparatus is disposed in such a manner as to cause a free circulation of air to radiate over the gas into the cooking-chamber, provision being made for the rapid escape of the products of combustion, steam, fumes, &c.

"The cooking apparatus itself may be of cylindrical, square, or other shape, and is made of a suitable mixture of fire-clay composition in one or more segments, of concave and convex form, with roof of the same make, thus causing a uniform concentration of heat all over the objects to be cooked or heated. The roof of large meat-roasters ought to be level with the floor-line, and made so as to be raised and lowered by a small crane, thus the frame to contain the meat is suspended from this roof, and when filled, is lowered into position with the roof, or, when the cooking is complete, then the roof, frame, and its contents are raised, and the meat withdrawn. By this contrivance a man can fill the apparatus with three hundred pounds of meat in eight minutes, or empty it in the same time. The dripping is drawn off to a vessel at some distance, where it is cooled at once. The heated chamber is surrounded by another cylinder or chamber, an air space being left between the two. This space is sometimes filled with non-conducting material, to prevent all external radiation of heat, but yet leaving a free channel for all the steam fumes and products of combustion to escape.

"Instead of setting the chamber below the floor it may be set on it, and in this case the roof is a fixture and segmental doors are fitted in the sides to swing open. Baking ovens are made square and lined with segments of tiles; while hot plates, for boiling, stewing, &c., are also fitted, and so supplied with gas that any degree of heat can be maintained at pleasure."

In order to explain the scientific action of this apparatus to our readers, we must tell them that the late Baron Bunsen discovered that by mixing a proportion of atmospheric air with the gas immediately before the ignition of the latter, its illuminating power was destroyed, but the heat was greatly intensified. The little kettle-stand, with a gas burner beneath—so common now—are exemplifications of the Bunsen burner. Besides intensifying the heat, there is a much more complete consumption of the carbon in the gas, thus whereas a common gas flame will blacken any surface, the Bunsen flame will not do so, and Mr. Leoni has turned these two features of the Bunsen burner to account in his cooking apparatus; while by the plan he adopts of completely enclosing the objects to be roasted in a non-radiating chamber, he utilises every unit of heat even more perfectly than is done in the common baking oven, while at the same time the meat, being exposed to the direct influence of the heat, is cooked with that peculiar crispness which is so distinctive a feature of roast as compared with baked meat.

With regard to the question so important at the present time, the working cost, we may quote from a report sent by Messrs. Leoni and Co. from Mr. Nixon, the House Governor and Secretary of the London Hospital in Whitechapel. He states in it that the working-out of the large roaster during 125 working days was such as to show a reduction in gas consumption from a daily average of 610 cubic feet to 250 cubic feet, showing thus a saving of 360. Under the old system again, the waste of meat in cooking was 33·3, while with Mr. Leoni's system the loss was only about 14·3 per cent. The actual saving to the hospital in 125 days was—in meat, 4,579 lbs., and in gas 44,525 cubic feet: or for a full year's work of 261 roasting days, nearly 10,000 lbs. of meat, worth, at cost prices, £296; and for gas about 88,000 cubic feet, costing £17 12*s.*; the total money saving being thus £313 12*s.* Mr. Nixon furthermore states that equal economy is to be expected when all the kitchen arrangements are complete; while as to disinfecting clothes, to kill vermin, &c., the gas principle, as applied by Mr. Leoni, is equally satisfactory, and as to cleanliness and saving of labour "it is difficult," says Mr. Nixon, "to exaggerate the advantages derived from the adoption of this patent."

Space forbids our adding more than a brief abstract of the report returned by Messrs. Harston, Architects of the Poplar Sick Asylum, at Bromley-by-Bow. This hospital is certified for 600 inmates, and the whole of the meat for the inmates and the officials is cooked in one of these kitchens with an average con-

sumption of 600 feet of gas; the ovens, owing to the dinners being served at different hours, are seldom filled, but the consumption of gas has been ascertained to average 1·25 cubic feet per pound of meat cooked, or 438 feet to 350 lbs., and this, at present gas prices, equals 17 lbs. of meat extra for one penny worth of gas consumed.

A RUSSIAN engineer named Sakhovsky has invented an apparatus—a kind of differential gauge—of very simple construction, which is said to have been found to work admirably at the Moscow terminus of the Nijni Railway, and on several other lines. The apparatus consists of a beam about 5 ft. long, provided at one end with an articulated lever, on the shorter arm of which is a stud that presses by means of a spring against the inner face of one of the rails, and at the other with a fixed stud; the beam is drawn along the rails by a man by means of shafts, or it may be attached to a truck. As the gauge proceeds along the line the deviations from the normal width between the rails is shown by the longer arm of the lever, which moves against a dial plate. The apparatus cost only eight roubles, and its superiority over the common gauge is striking, especially as regards the rapidity and continuity of the action. The directors of the Nijni and other lines have adopted the invention, which we believe is patented. Such a gauge run along a line every morning might prevent many an accident.

BUTTER-MAKING MACHINE.

A HANDY machine, interesting to the managers of dairies, will be found in the "Butter-making Machine." It is very simple in construction, and can be made very cheaply by any country carpenter and smith. The mechanical part of the apparatus can be adapted to any ordinary tub, A, in use by farmers, by means of the iron ring or hoop *a*. The ring or hoop is fixed to the barrel by the screw *b*, which allows of its being connected and disconnected at a moment's notice. The two upright pieces B B, forming part of the iron hoop, are furnished at the top with a couple of bearings, in which the axle

Fig. 1.

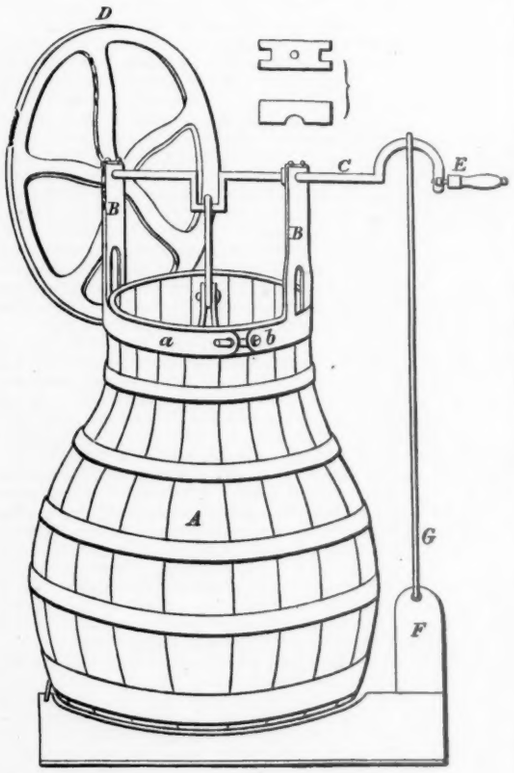


Fig. 4.

Fig. 3.

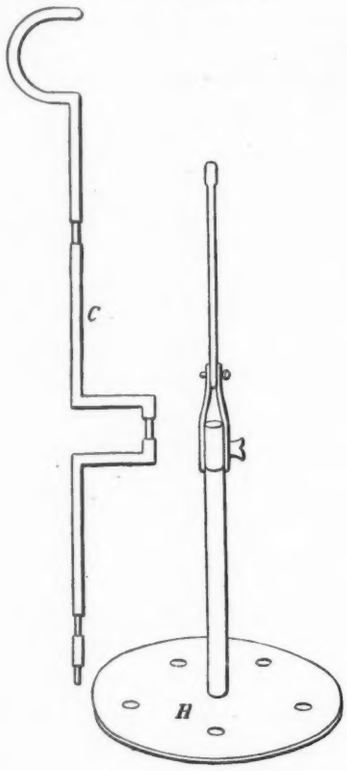
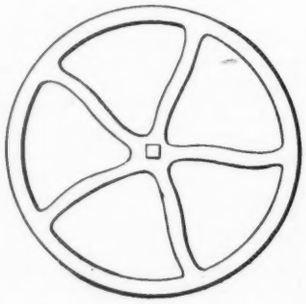


Fig. 2.

C revolves. At one end of the axle a wheel D, is fixed by means of a screw, and at the other, the handle E, to work the apparatus by hand. It can be worked equally well by the foot, by simply attaching a treadle, F, with a leather band, G. The

Fig. 5.



beater, H (see fig. 2), which helps to churn the milk, is fixed in a cylinder by a small screw which allows of the lid of the barrel being removed with facility. This cylinder is free to move in the axis of the barrel, so that it may always be maintained in a vertical position.

LUBRICANTS FOR MACHINERY.

(*Translated from a Note by M. D. Grothe in the "Bulletin of the Netherlands Industrial Society."*)

THE unctuous substances employed for lubrication are very numerous. It is now some years since, when the discovery of new sources of petroleum added immensely to the supplies of oil for lighting purposes at a low price, that it was generally thought that the cultivation of oleaginous seeds could not profitably be continued. On the contrary, the cultivation of the colza for the oil has never been conducted on so large a scale as it has been during the last few years; and the quantity of colza oil now employed for the lubrication of machinery only is greater than the total produce in earlier times.

The expenditure incurred for the lubrication and keeping in good condition of machinery are, it may be truly said, enormous; and any investigation of the relative value of different lubricants must interest more or less every consumer; and the more so, that new lubricating substances are every day brought into the market, many of which are only old lubricants mixed with other substances of less value. It behoves consumers, then, to test well the qualities of a new lubricant before employing it about machinery, lest they lose in pocket, and run the chance of seriously damaging their machinery.

The objects in lubricating machinery are two-fold: 1st. To diminish the friction of the rubbing surfaces. 2nd. To prevent the heating, and reduce as much as possible the wear and tear which naturally result from friction. Friction is produced whenever one body slides upon another, and the resistance due to such friction depends on the pressure of one body upon the other, and upon the nature and the condition of the surfaces in contact. The extent of the surface has no material influence on the quantity of frictional resistance. The heating of the working surfaces of machinery is a consequence of the friction produced by the interlocking of two rough surfaces, one passing over the other, and of the vibrations caused by this interlocking. When the surfaces get heated the friction increases, and the temperature rises rapidly.

The diminution of friction is, then, to be effected by filling up the inequalities of the surfaces that rub on each other, and so prevent vibration. Liquid lubricants are generally employed for the purpose of reducing friction; and solid greases for preventing heating, for which purpose they are melted so soon as heat begins to be generated.

The first class of lubricants comprise, water, vegetable and animal oils, and mineral oils. Vegetable and animal oils are extracted from the colza or rapeseed, the olive, neat's-foot, and the whale. Mineral oils are obtained by distillation from tar, petroleum, &c. The second class comprises, tallow, fresh lard, soap and palm oil. Powdered graphite, plumbago, and talc, may also be mentioned, together with certain artificial mixtures of fat, resin, water, and soda. It is scarcely necessary to say that these different lubricants cannot properly be tested in the same manner, as the test must be varied according to the result expected. For light mechanism with slight pressure, as clock-work, and cotton-spindles, the very fluid oils are best adapted; for heavy machinery with great pressures, as the shafts of steam-engines and rolling mills, less fluid lubricants are preferable. In certain conditions solid lubricants are preferable; lard, for example, is suitable for the shafts of windmills; and fresh soap, with or without the addition of plumbago, is successfully employed on toothed wheels with wooden teeth.

In trying the relative values of lubricants the following are the points to be elucidated: To what extent they reduce friction; during what length of time they preserve their lubricating properties; to what extent they prevent heating.

With these objects the fluidity of the oils is first to be determined. Take a glass tube about 4 inches long and $\frac{1}{8}$ inch diameter and draw out its lower extremity so as to reduce the orifice to one-sixteenth of an inch in diameter. Fill it up with each oil successively, and note the time required for each oil to run out and empty the tube. As the temperature exercises great influence on the fluidity of oils, it is necessary that they should all be brought to the same temperature for trial, say, to a temperature of 60° F. The number of seconds required for the complete outflow of the following fluids were:—

	Seconds.
Water	9
Linseed oil	88
Colza oil	142
Olive oil	195

showing that olive oil was more than twice as viscous as linseed oil.

But, sufficient fluidity is not alone sufficient as a test of quality. The next question is, how long does the lubricant retain its fluidity? Colza oil,—a non-drying oil,—is one of the best oils for lubrication. When pure, it preserves its fluidity for a very long time; whilst, if it be adulterated with linseed oil, it is turned in a few days, or, it may be, a few hours, into a viscous substance which hinders more than it assists the movements of machinery. To ascertain during what length of time any given oil continues in a fit state for lubrication, Mr. Nasmyth's simple apparatus is employed. It consists of a plate of iron 6½ feet long and 4 inches broad, on the surface of which five or six parallel longitudinal grooves are cut by the planing machine. This plate is placed on a table in an inclined position, one end being raised from 8 to 10 inches above the table. Small equal weights of the different oils to be tried having been weighed out, each sample is poured into a groove by itself at the upper end. After an interval of several days the distance traversed by each oil down the plane is noted; the length of time is also observed, at the end of which each oil is rendered sufficiently thick by oxidation to cease flowing. It is thus observed that neat's-foot oil is but slightly altered by exposure to the air, and preserves its fluidity for a very long time. Certain purified olive oils and fish oils of American manufacture, used specially for clock-work, preserve their qualities for a still longer time.

Again, there are certain oils which readily become acid, even if they do not become rancid. Colza oil, for example, when it has been recently expressed, and is mixed with water and a certain whitish mucus, easily turns acid. The fatty acids thus formed attack and corrode the metallic surfaces with which they are in contact. Colza oil, when refined, is preferable to the oil in its natural condition, provided that it is thoroughly cleansed of the sulphuric acid employed for its purification. For the lubrication of delicate machinery moving at high speed, as cotton spindles, colza oil thoroughly purified cannot be too highly recommended. The cost of purification is largely compensated by the economy of motive power effected, as well as by the reduced wear of the machinery, and the less consumption of oil. That the influence of the nature of the lubricant in the consumption of power is considerable, may be inferred from the fact that in an English cotton-mill of 50,000 spindles, the heat produced by the gas-light at night, rendering the oil more fluid, diminishes the power necessary to drive the mill to the extent of two horse-power. We are not sufficiently alive to the influence of good lubrication, which when neglected gives rise to notable losses. The test for acidification of oil is easily made by letting fall a few drops of it on a plate of brass; and the disposition to acidification may be judged of from the time that elapses before the oil assumes the greenish hue due to the oxidation of the copper.

The next important question is that of the lubricating power, that is to say, the proportion in which the friction is reduced by the lubricant, and the motive power economised. This is ascertained by means of McNaught's apparatus, which is very simple and cheap. It is mounted on a small frame, which is easily fixed upon a table. A small vertical spindle is turned by means of a grooved pulley and a pedal motion. The spindle carries on the upper end a small capsule, of which the bottom is flat and polished. The oil to be tried is poured into this capsule, and a small round polished disc is placed upon the oil, and pressed to the bottom with a certain force by means of a weighted lever like that of an ordinary safety-valve. On causing the spindle and capsule to revolve the movable disc is dragged round with it at a velocity all the greater as the lubrication is less good. The viscosity of the oil is measured by means of a small arm connected with the disc, which strikes a vertical needle forming part of a bent lever, of which the horizontal arm is graduated and carries a movable weight, which is adjusted so as to balance the resistance of the needle with the motive force,—namely, the friction. The comparative results thus obtained are simple and precise. This little instrument might be employed with advantage in all large establishments of machinery.

BELVALLETTE'S CARRIAGE FACTORY.[1]

(AVENUE DE L'IMPÉRATRICE, PARIS, AND AT BOULOGNE-SUR-MER.)

CARRIAGES have assumed a degree of importance in our domestic arrangements that lends a peculiar interest to everything connected with their manufacture. Thirty years ago the building of gentlemen's carriages (in France) was a speciality of some five or six particular firms; other vehicles of all descriptions were constructed by small makers, little if at all above the level of ordinary wheelwrights, who worked single-handed or at the best employed a very limited number of men. Now-a-days, more especially within the last ten years, several large establishments have sprung up, each of which does annually an amount of business equal to or exceeding the sum-total of the orders executed in the course of the year by all the best makers together in times past.

French carriages, and above all Paris-built carriages, now enjoy a deservedly high reputation in foreign countries, and, in nearly every part of the globe, compete advantageously with those of English make. This result is due to several causes. In the first place—thanks to the administrative labours of Baron Haussmann—Paris, which has become the chosen resort of wealthy cosmopolites, is now well supplied with excellent carriage ways, over which the lightest and most fragile vehicles may travel without risk. Again, Parisian taste, that marvellous *consensus* of the most finished critics of every clime, dictates the models; and the recent improvements in metal work of all descriptions, in the preparation of leather, in the fabrication of particular stuffs, and, last but not least, in the application of machinery to joinery and cabinet-work, allow these light and graceful shapes to be endued with the requisite degrees of strength, at a comparatively small cost. Not that the prices are in reality low, as a good carriage, well built and properly finished, must and always will command a good figure.

The details we shall give of the manufacture will show that the prime cost of the materials employed, and the time occupied in working them up, let the mechanical appliances be as perfect as they may, together represent an outlay that cannot be reduced except at the cost of the manufactured article.

We must not be understood to extend our encomiums on Paris-built vehicles to those in use for commercial and working purposes, as in this respect, contrasted with our English neighbours, we appear to be now worse off than ever. We need no intimacy with the details of vehicular construction to be struck with admiration at the hansoms, the vans, and the light carts that throng without impeding the thoroughfares of "the City." It would be difficult to conceive a more judicious allocation of strength, a more equable distribution of the load, a more perfect economisation of space, a surer and safer localisation of the centre of gravity. And, as though to render the contrast with the opposite side of the channel still more striking, the painting and varnishing of these vehicles is as carefully executed as in the best private carriages, in marked contradistinction to the coarse daubings of paint that conceal imperfectly, and even now by no means invariably, the handiwork of French cartwrights.

We shall not enlarge here upon the superior commercial enterprise of which the employment of these vehicles is an indication, nor upon the effects of the intervention of transport of this description on the prices of the articles delivered. These considerations will form the subject of a special chapter when we come to speak of railways. We must now revert to our immediate theme—Parisian carriages, and their manufacture.

In Paris the private carriage is not merely a means of conveyance; it is a good deal more. To each one of those who initiate and control the great social and political movements of the world's metropolis, his light *coupé* or miniature brougham is a daily need; to the capitalist, the financier, the politician, to all who require rapid locomotion combined with comfort, and withal a certain style, of which the carriage is the most ostensible token. Then there are the landaus and dress chariots of the wealthy, who aim at shining in Vanity Fair, the old-fashioned cabriolet, the mail phaeton, of which a few lingering specimens, rightly deemed antique, may still be seen; the ladies' Victoria, the dog-cart or phaeton of the rich young idler, the "mail-coach" of the amateur *whip*, who would display his skill in driving four-in-hand—all these come within the category of private carriages, although most of them even now are regarded in the light of fancy equipages.

Again, to many persons in Paris, who shun the public vehicles on account of their slowness and defective cleanliness, the ordinary private carriage is a necessity: to more it is a means of enjoyment. And surely, of all the devices adopted by the children of Adam for their better delectation, none are productive of more agreeable sensations than are afforded by riding in an open carriage, as it is borne smoothly and swiftly past other vehicles in motion. The critical glances at the steeds and trappings of the equipages that meet us or roll beside us, the hasty glimpses of the occupants, the sense of translation, and the soft, swaying motion induced in the sitter, combine to produce an agreeable feeling of languid ease never to be forgotten by those who have once experienced it. To one and all the private carriage is, besides, a mark of social position, separating its fortunate occupants from the crush and moil of the work-a-day world, and exalting them to a state of blissful pre-eminence above the pedestrian throng.

We need not wonder, then, that the trade has prospered. If the possession of a private carriage be one of the commonest objects of ambition, the desire becomes no less exigent when the object has been attained, to have one by the very best maker; nor is this unreasonable, as defects of manufacture, which in other cases would be merely productive of inconvenience, in a carriage may entail fatal results.

For a long while it was the fashion to procure the most stylish carriages from England, notwithstanding the heavy import duties imposed upon them, but since the last International Exhibition, where French-built carriages obtained the highest awards, the name of Belvallette, Erhler, Binder, and others, carry as much weight as those of the best English makers.

The first of the above-mentioned firms has extensive works at Boulogne-sur-Mer and Paris, where everything that can be so done advantageously is executed by machinery, at a considerable saving of cost, both in the aggregate and in items of individual detail, as the different operations, which formerly would have been distributed amongst thirty or forty branch establishments, can now be concentrated in one.

Although both establishments can now turn out a carriage complete in every respect, that at Boulogne is devoted more particularly to the mechanical processes of construction, and to the preparation of the wood and metal work employed in the business.

The establishment at Boulogne was opened in 1804—about the time of the formation of the camp there—by M. Belvallette *père*, whose inventive genius led him to attempt the solution of sundry mechanical problems, even with the imperfect appliances then available. The building and repair of the postchaises that travelled the road from Boulogne to Paris before the days of steam, gave a certain importance to the concern. M. Belvallette sent his two sons to serve apprenticeships with the best English coachmakers, whose superiority was then universally acknowledged.

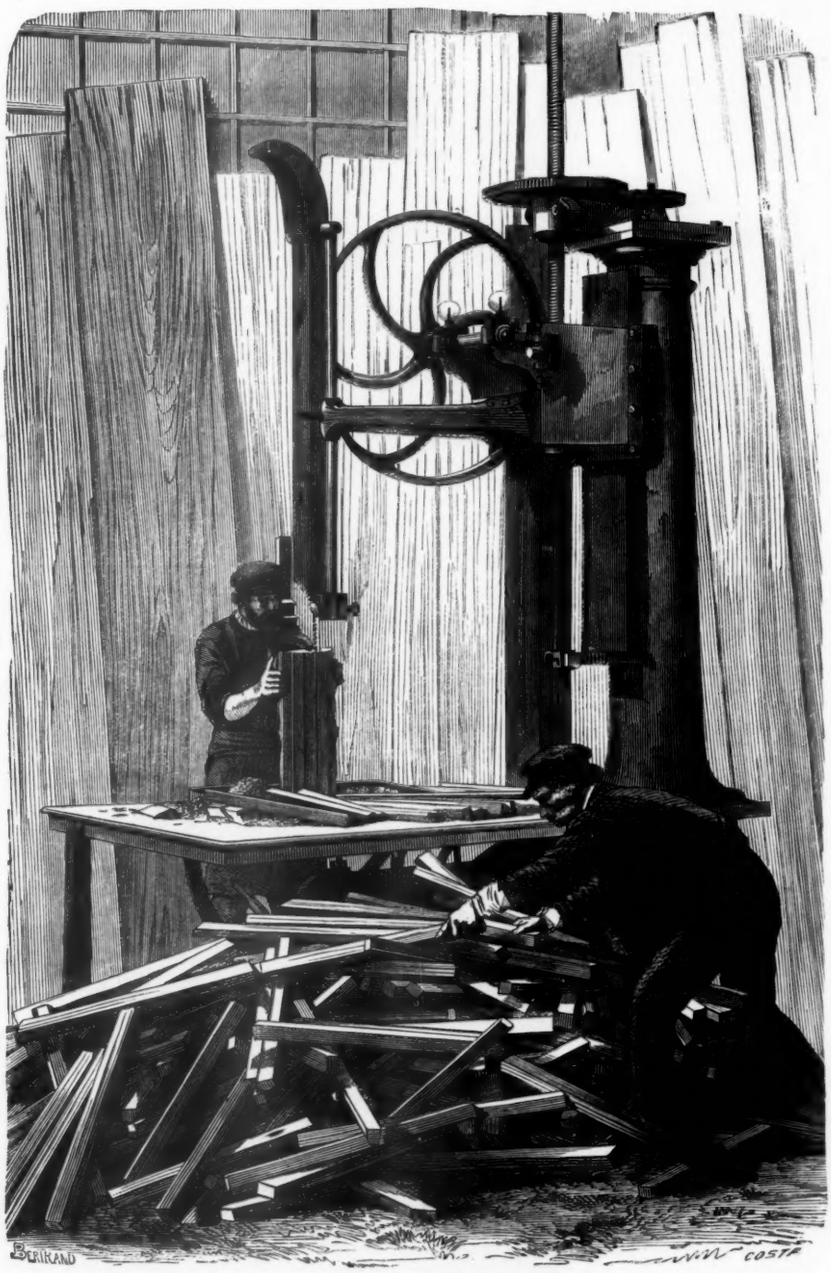
In 1840, the Messrs. Belvallette succeeded their father in the business; and in 1850, they opened their present establishment at 24, Avenue des Champs Elysées, with workshops in the adjacent Rue Bayard. These, having become insufficient in size, were replaced in 1856 by others in the Avenue de l'Impératrice.

In 1865, machinery was introduced at Boulogne and in Paris. One of the brothers undertook the direction of the works at Boulogne, the other is at the head of the new establishment. From this time forward, the two establishments, which in point of fact are one, have co-operated on the most advantageous principle. The Paris establishment is the directing centre. Here the supplies of leather, cloth, silks, horsehair, &c., can be purchased to the best advantage; and the taste is kept up to the requisite standard by the constant spectacle of a succession of the most elegant novelties. The works at Boulogne have an excellent staff of operatives, who have been connected with the concern for several generations, and who form a reliable nucleus. At Boulogne are the stores of timber, the age and soundness of which is a consideration of paramount importance in carriage-building.

In this respect the Messrs. Belvallette carry their precautions to an extreme. Not relying on stove or hot-air drying, and believing that nothing is equal to long-continued exposure to the atmosphere, they keep their wood for years stacked under open shed-roofs. Their timber-yards, of which they are very proud, contain over 200,000 francs' worth of wood cut up into large planks, each bearing the date of its admission to the yard. Every day huge trees are squared and sawn up to fill the gaps caused by the constant demands on the stock.

The woods most in request are ash and walnut for the body, elm for the mouldings, acacia for the spokes. As far as possible,

[1] *Les Grandes Usines*, par Turgan. 1874.



CUTTING SPOKES.

preference is given to timber from the roadsides and hedges, over forest-grown.

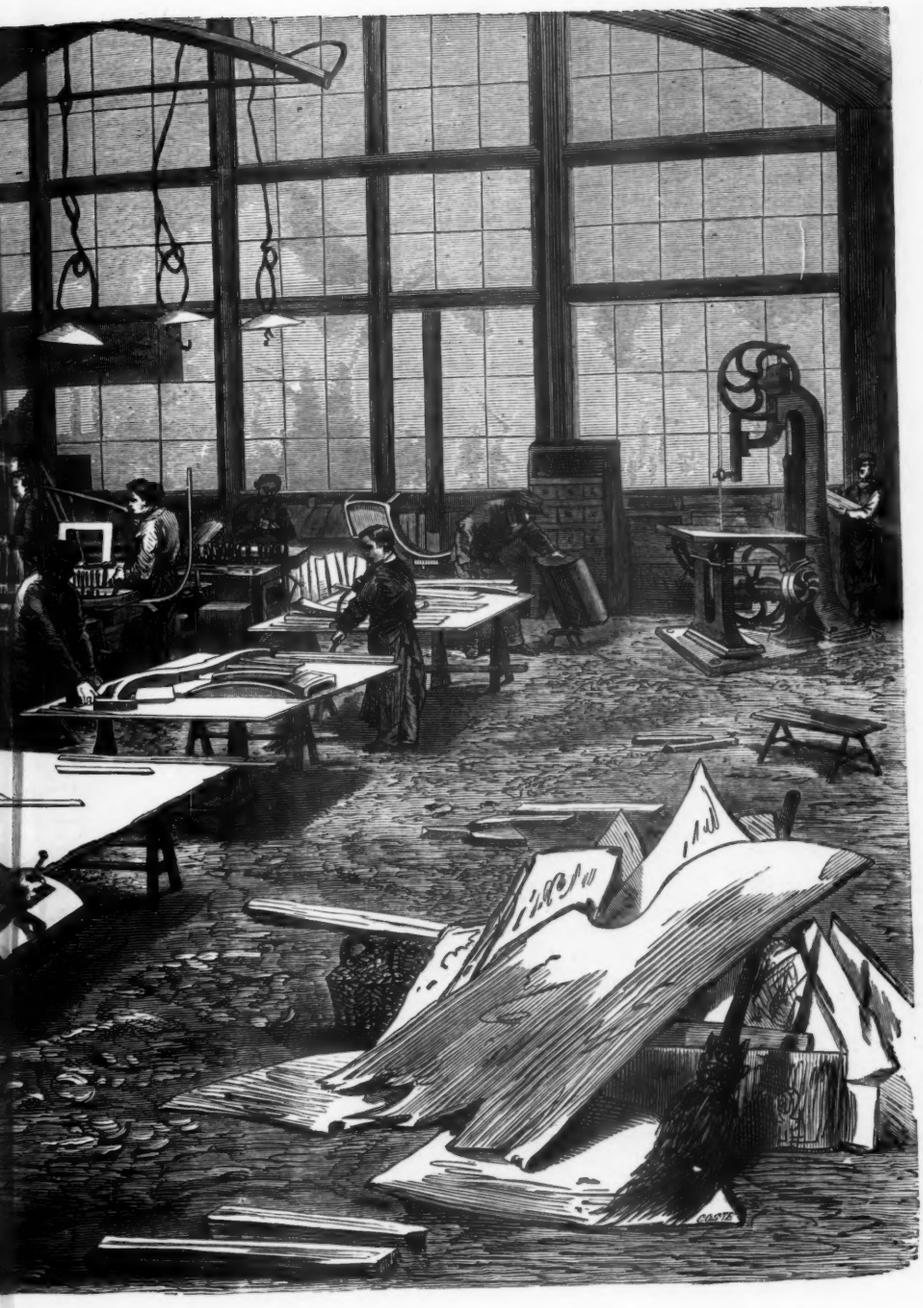
The requisite supply is readily obtained in the neighbourhood of Boulogne. Certain foreign kinds, as walnut and bay-mahogany, are most used; but the body frames, the felloes, and some parts of the under carriage, are made exclusively of ash, for the sake of its elasticity and durability. Acacia, which is used in large quantities for the wheel-spokes, is scarce in the neighbourhood; it is bought in Paris, where there is less difficulty in procuring it. This tree, the cultivation of which was so strongly recommended in King Louis-Philippe's day, has been in great disfavour with growers. As the steadily rising prices of carriage-work render it more profitable, it is unlikely that it will long continue scarce.

Acacia being very dear, the Messrs. Belvallette have endeavoured to economize it as much as possible, by getting the greatest number of spokes out of a block. For this purpose they employ Perrin's admirable circular saw, which cuts the wood to any length, breadth, or thickness desired.

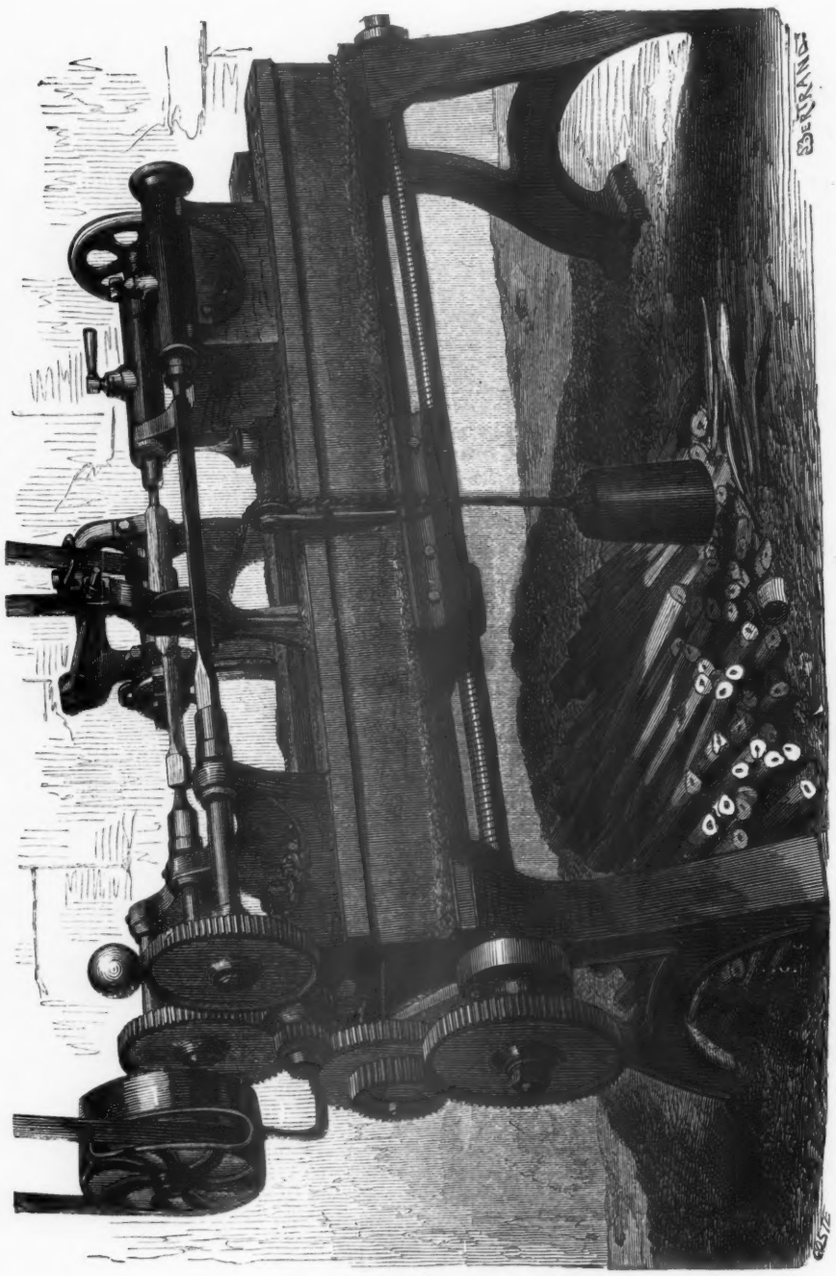
In place of being split down as heretofore, the blocks are divided into a series of concentric rings by the saw, and afterwards cut across, also by the saw, into quadrilateral prisms widening somewhat towards the outer extremities, so as to provide for the bevel of the spoke.

In this way nine spokes in place of six are got out of a single block, thus effecting a saving of one third. The acacia-wood, after being sawn up into prisms in Paris, is sent down to Boulogne, and stored in a large shed beneath the timber stores.

PART VIEW OF THE BO



E BODY-MAKERS' SHOP.

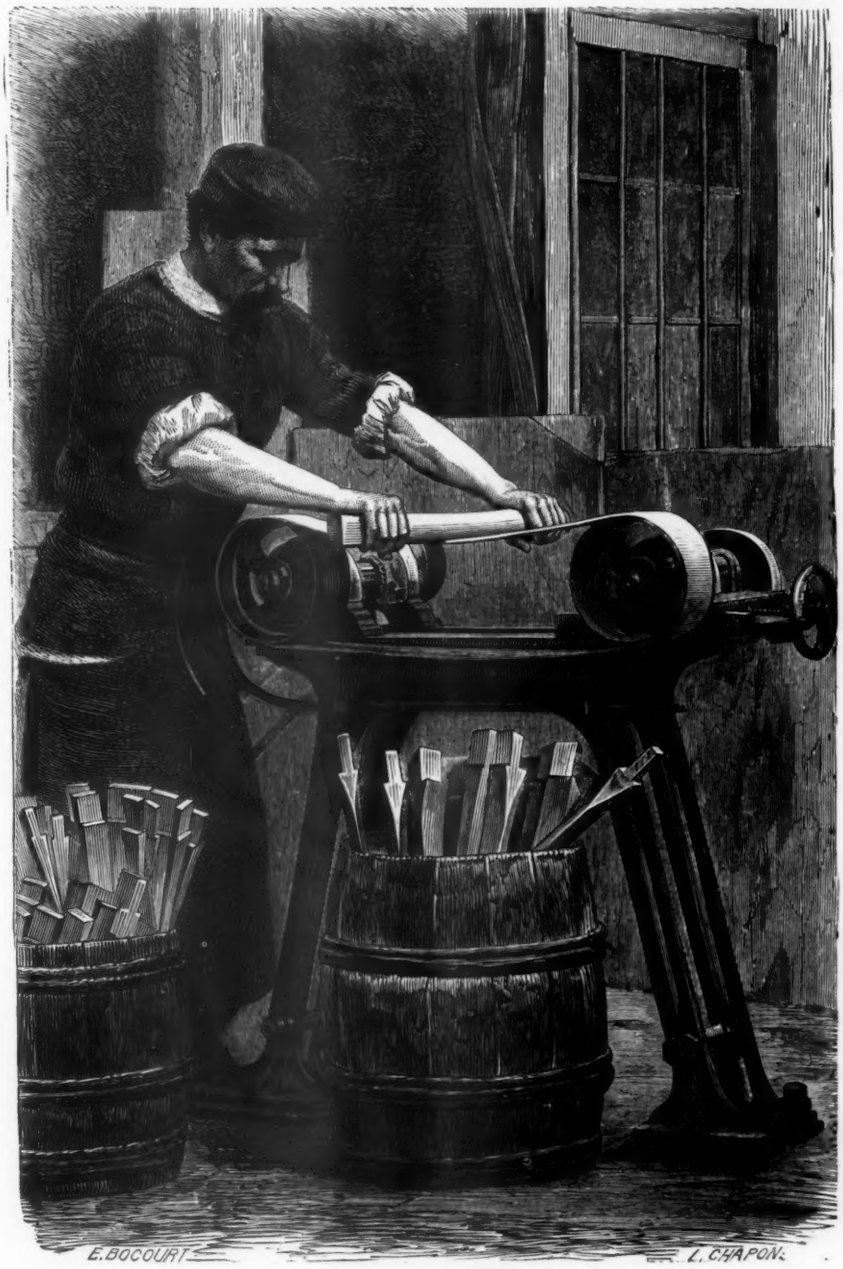


MACHINE-TURNING OF SPOKES.

At Boulogne, too, will be found a very nice assortment of wood-cutting machinery, admirably devised and arranged. We will glance briefly at the successive processes involved in the manufacture of spokes, which formerly were cut entirely by hand.

After a rapid preliminary roughing, the wooden prisms are placed, one at a time, in a pattern-lathe, similar to that used in turning out gun-stocks and boot-lasts, and which might be employed for a variety of other purposes, were it only more generally known. It is, undoubtedly, a very admirable machine, despite the apparent simplicity of its construction.

The form it assumes in the branch of industry of which we are now speaking may be thus described :—A massive cast-iron bed carries two pairs of parallel chucks, to which an uniform movement is given by a rack and pinion arrangement. Between the foremost pair is fixed an iron model or pattern, having the exact dimensions of the article required; betwixt the hinder pair is placed the prism of wood to be turned. In the space between is a disc, mounted on a slide, to which a regular transverse movement is imparted by means of an endless screw. In its progress, the edge of the disc rests against the surface of the slowly turning model; consequently it advances or recedes in a direction at right-angles to that followed by its slide, according as it meets with the elevations or depressions on the surface of the model. The movements of the disc are communicated directly to the puppet carrying the gouge, that works against the surface of the wooden prism, to which latter is given a rotary movement identical with that of the model. It follows, that the

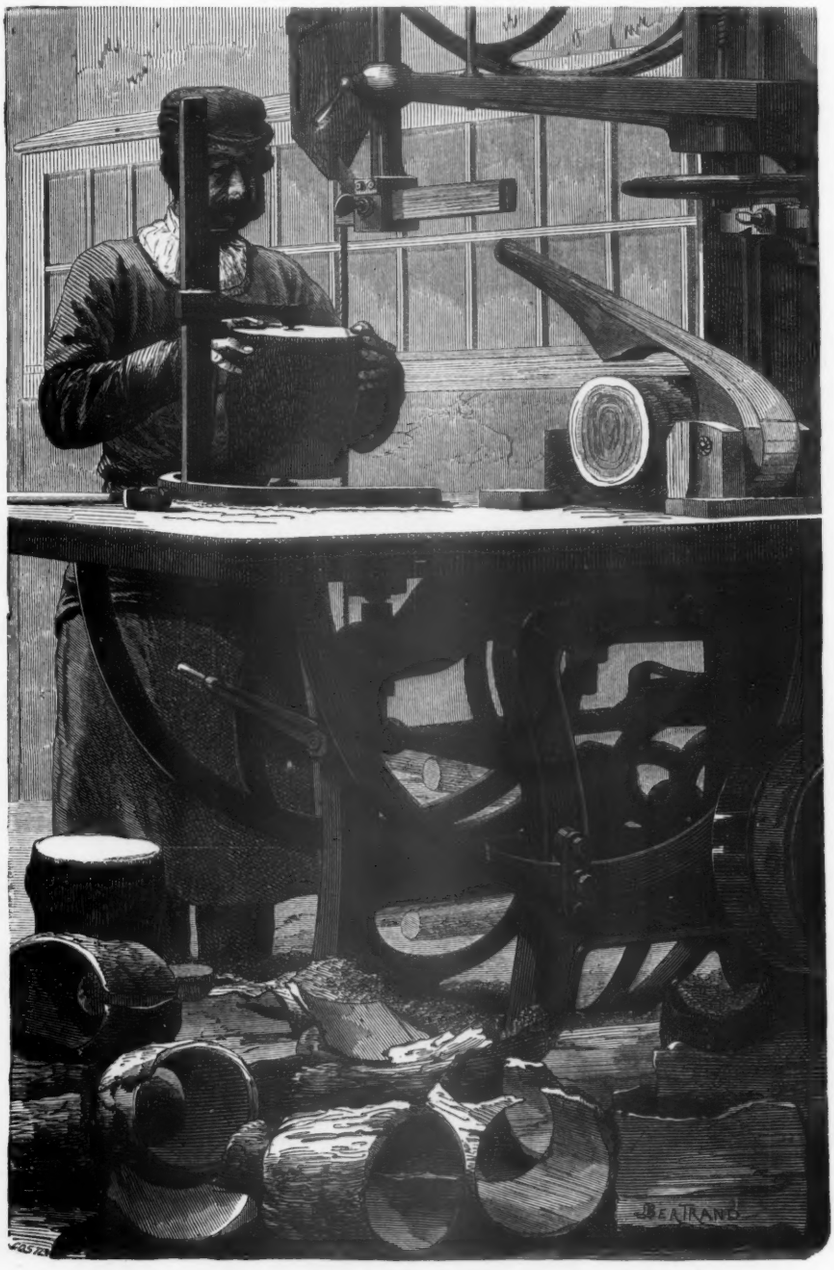


FINISHING SPOKES.

gouge cuts deepest into the wood when the disc is opposite the deepest depressions in the model, and, contrarywise, more and more lightly, as the same disc, in its transverse progress, follows the long inclined planes formed by the projecting portions of the pattern.

So accurately are the movements of every part of the machine now adjusted, that an indefinite number of spokes can be turned out, not only apparently, but mathematically identical with the pattern and with each other; a result that could never have been attained with the same precision and economy by the hand alone. But, carefully turned as they are, the spokes have to undergo a further preparation before they are fit to take the paint, as the gouge leaves traces on their surface, which, slight as they are, would be distinctly perceptible through the colour. Formerly they were taken off with the file, a tedious and unequal mode of procedure. M. Belvallette, son of the manager at Boulogne, conceived the idea of employing for the purpose a machine that might be usefully applied to many other branches of industry. Nowadays, the grindstone is often substituted for the file in removing burrs and polishing the surfaces of wood and metal work. But it has one drawback; however large may be the diameter of the wheel, the stone always presents a convex surface, which is only in contact with the object to be ground at a single point at once. When the latter is also convex in shape, as, for example, in the case of a gun-barrel, it requires great dexterity on the part of the workman to prevent the shape being altered in the process.

To obviate this defect, M. Belvallette passes a broad, stout



BARKING THE BLOCKS FOR WHEEL-STOCKS.

leathern strap over two rollers placed at a distance of 80 centimètres apart. The face of this strap is covered with some adhesive composition, and sprinkled with sand. A substitute grindstone is thus produced, having a plane face of 60 centimètres, capable of grinding a like extent of surface on any object presented to it, at a single operation. Moreover, as the strap is not strictly rigid, by bearing upon it a slight depression is produced, so that the grinding surface embraces the object to be ground, in place of being in contact with it at a single point at a time. The workman stands up leaning his breast against a sort of splash-guard, which keeps him from contact with the strap; he is not compelled to crouch upon a bench, as in other modes of grinding, and he has his arms at liberty to guide the movement of the wood, and to regulate its pressure on the strap as may be required. The spokes, after having been turned in the lathe, are thus finished off, at the rate of over 100 per hour, and thrown into tubs placed close at hand.

Other equally ingenious machines are employed in making the wheel-stocks, in which the greatest solidity is required, as they have to receive the spokes and enclose the axle-tree boxes. The stocks are made from round elm timber, of medium girth, which is sawn into suitable lengths, and the bark afterwards taken off with a Perrin saw.

To remove the bark and rough the wood into the form of a sufficiently regular cylinder, the block is placed on a table, and centred on a guide; the block and guide are then moved under the saw, until the latter bites the wood at the desired point; the block is then turned round on its centre, until it has taken the

BORING OUT BLOCKS FOR WHEEL-STOCKS.

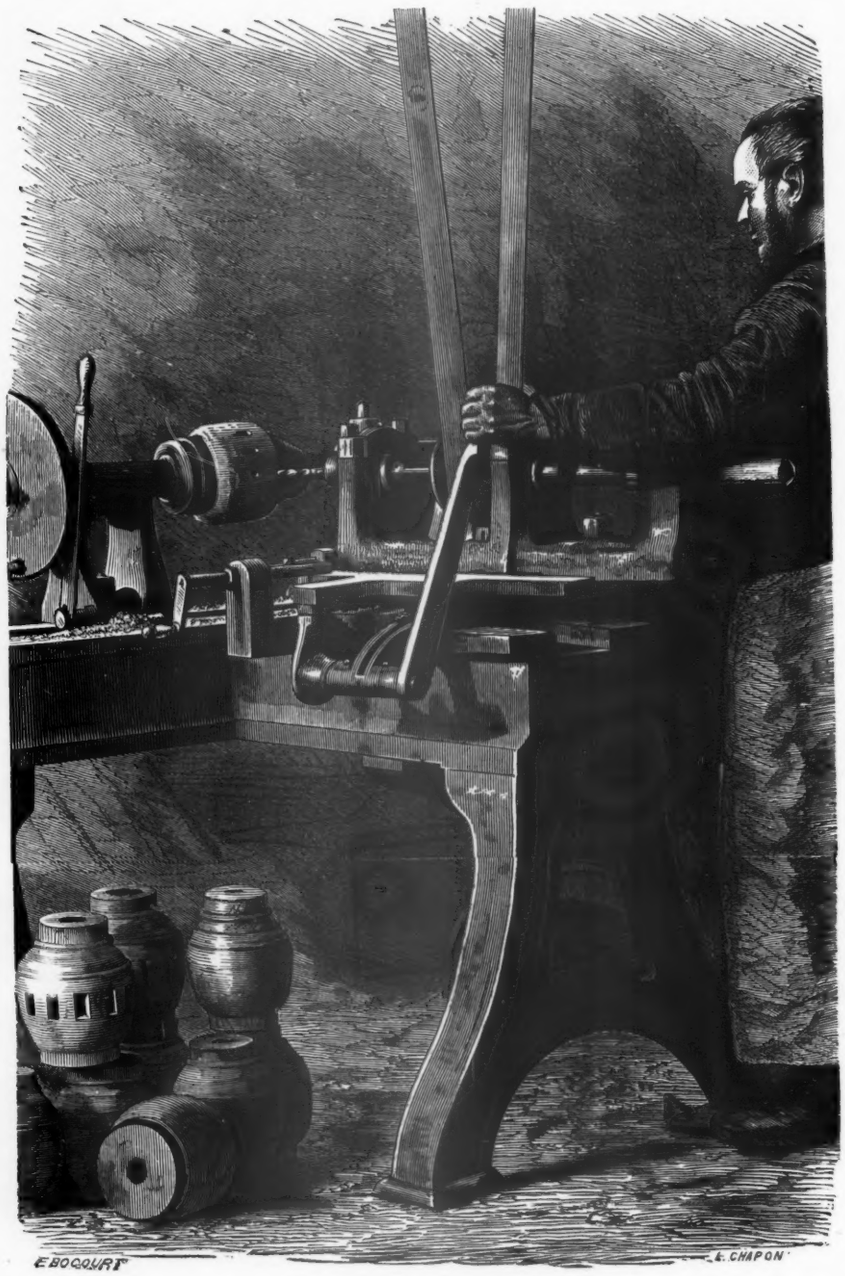
form of a regular cylinder, the flat ends of which are also submitted to the saw in turn.

The blocks are next bored out by a machine consisting of a revolving spindle, which the workman can raise or depress at will by means of a lever. The lower extremity carries a bit, which partakes of the rotary movement of the spindle, and forms the hole. The blocks are next turned to the required shape in a lathe.

The machine for cutting the mortises to receive the spokes is also a very good one. The stock is placed on a bench, and centred on an upright revolving axle, the rotary movements of which are indicated by a graduated plate, so divided as to correspond exactly with the intended relative positions of the spokes. The bit used in cutting the holes can be moved backwards or forwards by means of a lever handle, and is given a rotary movement as well, by means of a driving belt.

The workman charged with this operation moves the bit forward, by means of the lever, and cuts a hole at one extremity of the intended mortise; he then draws it back again; and the machine, by a movement nicely calculated, brings the other extremity of the mortise opposite the bit, which is again advanced, another hole made, and again withdrawn; another movement of the machine brings the space between these two holes opposite the bit, which is once more advanced, and quickly cuts out the intervening wood; so that when the bit is moved back for the third time the mortise is completed. The operator then turns the graduated plate, so as to bring one extremity of the next mortise-hole into the same position, and repeats the process.

This operation was formerly, and indeed is still in most places, executed by hand with the centre-bit and mortise-chisel. It was difficult to execute by machinery until the above ingenious mode of determining the rotary changes of position of a tool in rectilinear movement had been discovered. Besides the economy thus secured, the results are much more accurate than they



MORTICE CUTTING.

could possibly be if executed by hand-labour, no matter how skilled.

The felloes are cut out with a Perrin saw on templates previously prepared. When all the pieces are finished, the wheel is most carefully centred by a machine peculiar to the establishment.

All the pieces of the body, whether ash, walnut, or other wood, are cut out with the saw, and put together with very strong animal glue. To assure the *taking* of the glue, they are held together by strong cramps, which are kept on until the glue has set. Various modes of bending the wood are employed to produce the requisite curves.

All kinds of joiner's work are executed by hand in rare perfection. The tenons and mortices are all carefully fitted, and then well primed with white lead and linseed oil.

Whilst the operations just described are in progress, the smiths are preparing the iron-work. The iron is Swedish—the very best; the steel is of French manufacture. When all the parts have been carefully finished, they are fitted together by special workmen—*ajusteurs* and *limeurs*—who complete the carriage *en blanc*, as it is termed—that is to say, without the paint and trimmings. It is in this condition, where the quality of the materials and the workmanship can be seen at a glance, that the skilful builder delights to exhibit his work to his customers. When once the leather and paint have been put on, it becomes much more difficult to ascertain good qualities and defects.

The art of carriage-painting is amongst the most esteemed in the great field of decorative industry. Not, indeed, is it difficult

to paint a carriage badly; it is both easy and of common occurrence. But to produce one of those beautiful surfaces that may sometimes be seen, smoother and more brilliant than the choicest ceramic productions, and so hard and polished as scarcely to take the impression of the finger-nail, is a delicate operation, requiring both skill and time.

The successive coats laid on the body, from the first preliminary coat to the final coat of varnish, are twenty in all, sometimes twenty-two. After each application, a lengthy process of stopping and rubbing down is gone through, which requires the greatest care on the part of the operator, as a wrong touch may spoil all the foregone work. These successive coats are of five distinct classes—preliminary coats, primings, coats of body-colour, glazes, and varnishings. These are exclusive of decorations, such as lines and ribands of a different colour to the body, &c. As soon as all the parts of the body are ready, they receive two successive coats of white lead and linseed oil, care being taken that the first is thinner than the second, so that it may dry quicker; parts which eventually will be covered with leather receive a single coat only. The inside faces of the body pieces get one coat only, which is usually given with a mixture of refuse colours. Where the wood-work will not be covered with the linings, as inside the boot, a coat of better colour is given. The various portions of the under-carriage receive each a single coat; those that present a large surface, two.

When the carriage is put together, these preliminary coats are covered over with others, known as primings (*apprêts*), to the number of ten on the wooden surfaces, and twelve on the leather. The priming consists of a mixture of white lead and linseed oil. An interval of three days, at least, should be allowed between each repetition of the operation, to allow the previous coat to harden.

When time presses, another kind of priming is used, called *teinte dure*, which contains an admixture of a *drier* and some sort of gummy varnish, with the linseed oil. In either case the coat should be laid on sufficiently thick to bear pouncing, which is intended to remove any asperities from its surface. The pumice-stones are chosen of different sizes, to suit the different parts of the work to which they are to be applied: they are well washed in abundance of water and left to dry in the air. The operation of rubbing-down is repeated with a softer kind of stone.

The application of what is known as *body-colour* commences with a coat of lead-colour, which should be thoroughly ground before the linseed oil is added. This coat is known as the ground coat (*couche de fond*). When the final tint is to be light yellow, white is substituted for lead-colour; in like manner red replaces the latter when the colour is to be a shade of crimson. Upon this ground-coat are executed the stoppings (*remplissages*), which are designed to fill up nail-holes and small fissures or inequalities that may have remained on the surface of the wood.

The putty used for the purpose should be made of the very best materials—linseed oil and white lead, both of the purest quality. After stopping, the pouncing should be repeated more carefully than before; after which the whole surface should be lightly gone over with glass-paper, to ensure the disappearance of all unevenness. It then receives its first coat of black, if the colour of the carriage is to be dark; of white, if the colour is to be yellow; or of red, if it is intended to be of a crimson shade. To get what painters call a good *depth*, two coats of black will be required; and when they are dry and hard, the surfaces are gone over with a cloth dipped in pumice dust. The colour may then be laid on. Light colours require thinner and more numerous coats than darker ones. The glazes are very light, transparent coats of more expensive colours, designed to bring out and enhance the effect of the others.

Before the varnish is applied, the surface must undergo a series of rubbings down with a cloth dipped in pumice-stone ground in water, and after each coat of varnish this polishing process is repeated, until a surface is obtained smooth as ice.

Rechampissage—which is the addition of the stripes, bands, beadings, &c., of other colours, gilding, and other decorations—follows. The carriages of the present day are very sober in the matter of ornament, and the process is sufficiently easy; there is little beyond some armorial blazonry on gala carriages, to give scope to the artist's skill. In former days it was different, and the gilding, and above all the herald painting, required artists of no mean ability, as may be seen by the specimens of eighteenth century workmanship in the South Kensington Museum.

Finally, after a light rubbing-down with a rag dipped in whitening, an energetic washing and dusting with a badger's-hair brush, we must, as M. Gastellier tells us, in his "Manuel du peintre en équipages," "lay on the last coat of varnish boldly, and in sufficient quantity to *run* (*bondir*)." If the varnish will not *take*, there is no help for it; the rubbing down and varnishing must be repeated from the commencement.

The trimmings with which a carriage is completed vary greatly with the description and style of the vehicle; the beauty and the wear depend entirely upon the choice of materials. With the Messrs. Belvallette the selection is an object of special solicitude. The leather, morocco, cloths, silken stuffs, *passementerie*, and other trimmings in the magazine of their factory in the Avenue de l'Impératrice, are all of the very best quality, the enamelled leathers from the best houses in Paris and Pont-Audemer, the cloth made to order at Elbœuf, the morocco real goat-skin, not sheep-skin worked up in imitation. The silken stuffs are satin goods of Tours make; *cotelines* and reps are not much used, their defective German workmanship having brought them deservedly into disrepute.

Country carriages, one-horse dog-carts, and all kinds of light traps with two or four seats, of which the Messrs. Belvallette build a very great number, are fitted with leather or *étoffe d'Amiens*, which stands exposure well, and is very durable.

Not content with their successes, the Messrs. Belvallette have assiduously devoted themselves to the improvement of carriages of existing models, and to the introduction of others especially adapted to the requirements and tastes of the day. Thus, they have paid particular attention to the construction of landaus, a style of vehicle which, perhaps, is the most convenient of any for double use, either as an open or close carriage. For a long while the landau was in great disfavour, on account of its manifold imperfections of shape; latterly, the calèche, which has more graceful lines, and a more manageable head, has been very generally adopted; but in the calèche, in the event of rain, only two of the occupants are covered, and should it be thought necessary to put up the glasses altogether, it can only be done at home; whereas, in the landau, all the occupants are covered, and if the door-glasses be pulled up, the carriage will be as completely closed as a berlin.

At the last International Exhibition were numerous specimens of landaus with heads worked from the inside; but the various systems thus exemplified were not considered by the Messrs. Belvallette sufficiently perfect for adoption, as for the most part they were cumbersome, complicated, and uncertain in their action, entailing the necessity of frequent and oftentimes difficult repairs.

As a rule, the heads of landaus do not meet well in the middle; and if the contact be not perfect, the rain finds its way in. The Messrs. Belvallette have substituted for the old tenon and square mortise fastenings an arrangement of conical studs and sockets, so that when the two ends of the heads are brought opposite to each other, the points of the conical studs face the widest portion of the sockets, where as soon as they enter, the play of the head works them home.

The old-fashioned landaus were heavy in point of appearance and in draught; and the arrangement of the glasses rendered it necessary to have large deep heads, so that persons seated within appeared sunk in a chasm, the sides of which concealed every part of them but their heads.

It has been proposed to fold the glasses in a double tier, to allow of their being fitted into a shallower boot, which gives greater elegance of outline to the vehicle itself, and allows the figures of persons seated therein to be distinctly seen.

By these and other improvements the weight has been reduced to the extent of nearly 100 kilogrammes. General Morin, in his Report on the London International Exhibition of 1862, expressed himself thus:—

"As I have spoken of the lightness of the carriages, it may be as well to give their average weights, so as to show the limits within which they vary with different builders. Messrs. Belvallette, who may be considered our best makers, give to their carriages the following average weights:—

Berlin	650 to 700 kilog.
Coupé Brougham (4 seats) .	440 kilog.
Coupé (2 seats) . . .	320 „
Calèche for one horse . .	455 „

"Amongst our other builders, the average weights are as below:—

Berlin	650 to 700 kilog.
Coupé Brougham (4 seats) .	530 to 550 „
Coupé (2 seats) . . .	475 to 500 „
Calèche for one horse . .	480 to 500 „
Four-wheeled cabriolet, known as a "Victoria" or "Milord"	380 to 425 „

"In the carriages of which I have spoken, the weights of the several parts are proportioned pretty nearly as they appear in the annexed table:—

PART VIEW OF HE

HE SMITHS' SHOP.

Description of Carriage.	Body.	Under-carriage and wheels.	Iron-work and Lamps.	Seats.	Paint.	Trim-mings.	Total.
Berlin	0.287	0.086	0.520	0.014	0.015	0.078	1.000
Coupé (4 seats) . . .	0.282	0.058	0.537	0.018	0.019	0.086	1.000
,, (2 seats) . . .	0.260	0.066	0.560	0.018	0.017	0.080	1.000
Calèche, one horse .	0.222	0.067	0.590	0.018	0.010	0.103	1.000
Cabriolet with four wheels, or "Milord"	0.210	0.074	0.590	0.023	0.010	0.093	1.000

"The foregoing details show that the substitution of iron for wood gives a certain appearance of lightness, but this is only attained by an increase in the relative weight of the iron-work, which forms 50 per cent of the total weight, and more in proportion as the carriage is lighter. The substitution of steel for iron would allow of a notable reduction in the weight. We see by the above, how the weight may be reduced by a careful attention to matters of constructive detail and a judicious choice of materials."

Another improvement, which greatly lightens the appearance, is the substitution of steel plate for the heavy combination of wood and iron forming the bottom of ordinary landaus. Increased facilities are thus afforded for stepping in and out of the carriage, as there is no risk of the feet coming in contact with the bottom sides.

By adopting these improvements Messrs. Belvallette have produced a landau light and elegant in appearance, and sufficiently light in point of actual weight to be drawn by one horse without distress. It makes an excellent carriage either for summer or winter use, and may be driven with one horse or a pair, as may be desired. To show that French builders were not so far behind their English brethren, the Messrs. Belvallette sent to the International Exposition of 1867 a "mail-coach," which received special mention by the Jury in the following terms:—"Three mail-coaches, of most perfect make, were sent in for exhibition; of these, two by Messrs. Hooper and Peters, of London, are in the English section; one in the French section is by the Messrs. Belvallette *frères*, of Paris. Until very recently English makers have monopolised the manufacture of these vehicles, designed for carrying a large number of persons to race or hunt meetings, and they have introduced many notable improvements in the construction of private carriages of this particular type. The development in France of a taste for sport and grand equipages has induced French builders to turn their attention to the same class of vehicle. The specimen produced by the Messrs. Belvallette, which has received a special award in Class 61, shows intending purchasers that hereafter they need not look across the Channel for carriages of this description, the building, hanging, and embellishment of which require a combination of the mechanical knowledge of the engineer with the taste and skill of the manufacturer. If the English builders have fully maintained the high reputation they had already acquired, French makers have at least shown that they are competent to execute orders for the same class of article with credit to themselves and satisfaction to their customers."

That the above was not merely a show effort, is proved by the fact that on the occasion of a recent visit to the works at Boulogne and in Paris, we saw *three* such drags in process of construction.

The most noticeable inventions for which we are indebted to the house of Belvallette *frères* are the following:—

1. The articulated shaft (*brancard articulé*), for two-wheeled vehicles, which entirely obviates the jolting motion caused by the horse's trotting. This improvement is in great favour with owners of two-wheeled carriages, and a great number of dog-carts, tilburys, &c., have been fitted with it. In many rural districts a two-wheeled carriage is a necessity. Our country roads —not only the forest tracks, but many of the roads near towns —are quite unsuited to four-wheeled carriages; and many persons, not unreasonably, think it easier to adapt the carriage to the road, than to attempt to improve the roads to suit four-wheeled draught. In two-wheeled vehicles the jolting is an undeniable objection, and the Messrs. Belvallette have earned our thanks by providing a remedy for it.

2. The employment of steel-plate bottoms for open and close carriages, thus getting ride of the clumsy bottom-side, over which it was necessary to step on entering or leaving the carriage. This invention is greatly approved by ladies.

3. A new mode of bolting the fore-carriage to the body of the vehicle, giving increased stability to the latter, greatly increased simplicity in the construction of the fore-carriage, with superior strength in the bolt itself. This arrangement allows the horses to be attached closer to the body of the carriage, which is an essential condition of good traction.

4. A new bell-catch for carriage doors. It gives a securer fastening than the old-fashioned lever catch, and avoids the risk of tearing the side-pockets of overcoats and the trimmings of ladies' dresses, entailed by the use of the latter.

5. An improved iron shaft-tug, for two-wheeled carriages. It is constructed on the principle of a soldier's bayonet-fastening, and allows the shaft to be lengthened or shortened, elevated or depressed, to suit the horse's height. The play of the tug, which is in the form of a double right angle, allows the hinder extremity of the shaft, and consequently the position of the shaft itself, to be adjusted at will.

6. A new arrangement of glasses for landaus.

7. A coupé-cab, on a new principle, much lighter than the ordinary coupé, for which it will be found in most cases an advantageous substitute. The coupé-cab has four wheels, with the fore and hind axletrees very close together, giving greater lightness and increased facilities for turning in a small space—an important advantage in Paris, where carriage-room of every kind is scarce.

These inventions, and the introduction of various improvements, either original or copied from the practice of the best foreign makers, have acquired for the Messrs. Belvallette the highest rewards, and amply entitle them to the prominent position they occupy in their own special branch of industry. At every International Exhibition they have taken first-class medals, amongst which may be mentioned—

Prize Medal . . .	London .	1851.
Medal First Class .	Paris .	1855.
Prize Medal . . .	London .	1862.
Gold Medal. . . .	Paris .	1867.

THE TESTING OF CHRONOMETERS AT GREENWICH OBSERVATORY.

So important is the correct timing or going of chronometers to the determination of the longitude, and of many problems in astronomy, geology, hydrography, geography, and navigation, that the English Government have established a system for testing the accuracy of these delicate instruments. The thoroughly organized staff of the Astronomer Royal, Sir George Biddell Airy, comprises men who devote a portion of their official time to this duty at Greenwich Observatory. The government do not make themselves reponsible for the chronometers used by the mercantile marine; the supervision relates to those employed in the Royal Navy. Some persons urge that this protection should be thrown over ships engaged in commercial and emigrant enterprise also; but there is much cogency in the reply that it would be dangerous to shield ship-owners and captains from direct responsibility under any such plea that the State must bear the blame when anything goes wrong. There is an indirect mode, however, to be explained presently, whereby commerce benefits by the testing of chronometers at Greenwich Observatory.

A mistaken notion is widely diffused that a chronometer ought always to be right to a second of time, or even the fractional part of a second. This, though desirable, is not indispensable; and we may reasonably doubt whether such rigour is ever really attained in practice. What is wanted is the maintenance of a uniform *rate of change*, whether too fast or too slow. If, for instance, a chronometer is found to be exactly right on the 1st of the month, one tenth of a second slow on the 2nd of the month, two-tenths slow on the 3rd, three-tenths slow on the 4th, and so on, the deviation from accuracy would not be a fatal evil; if not altered by the regulator, that particular chronometer will bear the character of increasing its slowness one-tenth of a second per day. We do not stop to enquire how far these supposed numbers harmonize exactly with the records of any one instance; the reader will see the point of the illustration—the value of a regular rate of variation, if absolute accuracy cannot be attained. But suppose the variation to vary in its rate; that the chronometer advances one-tenth of a second the first day, three-tenths the second day, two-tenths the third day, five-tenths the fourth day; such a chronometer would embarrass its user, who could not safely rely on any particular rate of advance or recession on any particular day. Still worse would it be if the changes were rapidly from *plus* to *minus;* a fraction too fast one day, a fraction of different value on the losing side on the second, and so on.

Alternations of heat and cold are the main causes of irregularity in the going of chronometers. In hot weather all the metallic portions of the exquisite machine expand a little, and affect the elasticity of springs, &c.; in cold weather they shrink,

and influence the delicate working in an opposite way. It might be supposed that, as all metals expand by heat, all parts of the chronometer, equally enlarged (though in an insensibly minute degree), would work together just as well as before. But such is not the case. Steel and brass have different degrees of expansion for every degree of elevation of temperature, and corresponding differences of contraction for every degree of lowering of temperature. Hence arise the wonderful variety of *compensation balances* and *pendulums*, by which chronometer makers, especially English, have sought to counteract the tendency of one metal to expand more than the other. The inventions of Harrison, Mudge, Earnshaw, Arnold, Dent, &c., to bring about the desired result, are among the highest examples of systematic adjustment applied to mechanical execution.

We cannot here describe the construction of these beautiful instruments; we have only to deal with the testing. We will suppose one of Her Majesty's ships to arrive at Portsmouth to be paid off, and will follow the fortunes of the chronometers which are on board. Every chronometer has the maker's name and a number engraved upon it; insomuch that its identity can always be insured, and its personal history, so to speak, traced.

When the chronometers reach the Observatory, they are examined for rust, breakage, and general condition. If in good order, they are placed among others in store, rated or timed periodically, and issued to other ships when wanted. If repairs are needed, notice is given to the makers, whose names are engraved as a record; they notify the work needed, and the probable cost. If the Astronomer Royal is satisfied with the report, the repairs are effected, the chronometers are returned to Greenwich, and there subjected for several weeks to hot and cold tests, presently to be described; and not until these tests have been thoroughly and properly borne are the perfected chronometers placed in store.

More interesting, however, is the testing of new chronometers —those which have never been out to sea. Until about half a century ago the Astronomer Royal did not test any chronometers belonging to private persons; but in 1822 a new system was introduced. A maker having produced a piece of work in which he took pride, was permitted to send it to the Observatory, there to undergo a long and severe ordeal. If the report were favourable, not only did it give a high value to that particular chronometer, but it enhanced his reputation as a maker. So well has the system worked that it has been continued ever since, with improvements in detail. No charge is made by the Government for testing; but the maker of an inferior instrument has little inducement to compete, seeing that the bad performance of his particular chronometer is set forth in a paper printed for circulation among the trade in general. The only way to do justice to excellent workmanship, is to be equally candid in regard to that of less merit. The Government began, in 1822, by offering £300 for the chronometer which bore all tests most satisfactorily, and £200 for the next best. In later years the same total sum was divided into three prizes of £200, £170, and £130; but by 1826 the chronometers generally had become so excellent that no further incentive of this kind was needed. Instead of this, the Government purchase some of the best each year, to keep up the number in store, at a good but not extravagant price.

The plan adopted is as follows:—A maker, wishing to have a chronometer tested, applies to the Admiralty for permission. Some of the most eminent apply in regard to two or more, but generally one is the limit for each maker. Permission being granted, the chronometers are taken to Greenwich Observatory on an appointed day. This day is usually a Wednesday early in January, and on the following Saturday the testing begins. First comes the test for *cold*. No artificial cold or freezing mixture is employed. The chronometers are placed under a kind of penthouse outside the north window of the chronometer-room, protected from rain and sun, but exposed to cold and wind. Here they are kept during the greater part of the winter. If any one chronometer has not been perfectly balanced or compensated, the fact is sure to shew itself; for the shrinking of the metals under the influence of cold affects the rating or time, and if the compensation is either over or under the mark, the instrument will probably become not only wrong, but *irregularly* wrong—one of the worst faults that a chronometer can possess.

Then comes the test of *heat*. This heat is produced artificially, because in our variable climate a steady high temperature seldom maintains itself for a long time together. The chronometers are placed within a chamber or stove heated by gas. The stove is double, inner and outer, a space being left between the two on all four sides and the bottom; it is closed by lids opening upwards. A row of eight small gas jets heats the space between the inner and outer casings; by which means the inner chamber is surrounded on the sides and underneath with a warm jacket. The products of combustion are carefully carried off. A wooden case outside all serves to equalize the temperature. The chronometers are supported in the inner chamber on light wooden laths, and do not touch the iron. For weeks together they are exposed to the warm temperature, and are frequently tested to see whether the earth's magnetism affects them. They are placed face upwards, face downwards, edge upwards, the XII at the top, the XII at the right or left hand, &c.—all positions in turn. We may here observe that the result of these tests is satisfactory to astronomers and navigators. No perceptible effect is traceable to mere change of position, so far as the magnetism of the earth is concerned. Magnetic influence brought about in other ways is, however, observable in the balance-spring; and the Astronomer Royal has devised the following mode of testing it:—The chronometer is placed on the top of the compass-box, at a height above the compass calculated for each individual chronometer; the needle is perfectly free to move within the compass. If the balance-spring is magnetic, the degree of this defect determines whether a new one must be made. The chronometers are next exposed for three or four weeks to a somewhat higher temperature—about 96° to 100° Fahr. They are then taken out of the stove, and kept quiet in the chronometer-room until July, making altogether half a year of severe testing. They are rated every day; that is, the degree is observed and recorded of their deviation from strict accuracy.

When all the instruments have passed through this formidable ordeal, the Astronomer Royal reports the result to the Admiralty, who decide whether to purchase any of those at the head of the list, and how many. As the authorities do not like to accumulate a larger stock than is necessary, they retain this decision quite in their own hands. The makers say that the price, high as it is, does not more than pay them for the extra pains they devote to the work; but the reputation gained has a decided though not calculable money value, especially to new or young makers, who are anxious to stand well in the Astronomer Royal's report. When an offer to purchase is made and accepted, the chronometer is returned to the maker to be cleaned and brought into perfect workable order. All others must be removed from the Observatory by the makers on a stated day.

In preparing the tabular statement of results, the Astronomer Royal observes many precautions, with a view of being as just and impartial as possible. The daily rate of change in the excellent chronometers now made is so minute that the tables are not burthened with them; it suffices to give the weekly rates. There are three sets of tables, in all of which every chronometer occupies a place. The first gives the weekly rates for every chronometer, arranged in order of date from January to July. The second in like manner gives the weekly rates, but the weeks are arranged in the order of temperature, as determined by a chronometrical thermometer. The third gives the *least* weekly rate for each chronometer during the whole period of the testing, also the *greatest*, and the difference between the greatest and the least. In order to determine whether any change of rate in any one chronometer is sudden or gradual, two entries are made—the one to show the difference between the greatest and the least rate, and the other the greatest difference between any two consecutive weeks. One of these evils in a chronometer—the change of rate from one week to the next—would practically be more serious than the other. The Astronomer Royal takes this into account in deciding the relative merit of the instruments by establishing trial numbers. The trial number for any one chronometer is equal to the difference between the greatest and least weekly rate, *plus* twice the greatest difference between one week and the next; that is, one of these two kinds of fault is considered to be twice as serious as the other, and is debited accordingly. This is believed to lead to a very fair estimate of relative merit.

The chronometrical thermometer, above mentioned, is based upon the observed fact, that at all ordinary temperatures, say from 30° to 100° F., an uncompensated balance will vary about six seconds daily for each degree increase of temperature, on account of the change produced in the elasticity of the balance-spring. The balance corrects this by having the outside made of brass and the inside of steel. The chronometrical thermometer acts as a test; it has the two metals in reverse order, the brass *inside* the steel. A calculated table affords the means of determining the working of the uncompensated balance, by this double series of unequal expansions.

A marked improvement has been observable in the chronometers tested at Greenwich. A larger percentage reach a high standard of excellence now than at any former period. In 1851 only 1 in 4, or 25 per cent. had the difference of rate between the greatest and least weeks less than 10 seconds; in 1865 the proportion was 1 in 2, or 50 per cent. In another mode of estimating the test, 1 in 5, or 20 per cent., kept within 10 seconds as the greatest difference of rate between one week and the next

in 1851; whereas in 1865 these fine specimens rose to 63 per cent. An acceleration of rate is often observed which can with difficulty be traced to its source. The more usual cause is found to be over-compensation. The makers themselves subject their chronometers to a heat test; but the Astronomer Royal believes that this is not continued long enough. Commenting on this matter in 1860, he said:—"The material workmanship of all the chronometers is good, and amongst them the difference in this respect is very small indeed. In uniform circumstances of temperature, every one of the chronometers would go almost as well as an astronomical clock. The great cause of failure is the deficiency of compensation or the too great compensation for the effects of temperature. Another serious cause of error is brought out clearly in the trials: viz., a fault in the oil, which is injured by heat. This is very different with the chronometers of different makers. For instance, the oil used by one maker is not at all injured by heat; while some of that used by another maker is so bad that, after passing through the same amount of heating, the rate of a chronometer is changed (on returning to ordinary temperatures) by as much as 80 seconds per week. I believe that nearly all the irregularities from week to week, which generally would be interpreted as proving bad workmanship, are in reality due to the above-named cause." This may serve to explain the almost incredibly high price of watch and chronometer oil; the very finest kind, which will bear all tests that can be applied to it, commands six guineas per pint, owing to the long, tedious, and careful processes that it undergoes, and the necessary rejection of many of the specimens when they have gone, perhaps, through half the ordeal.

In 1869 the middle room of the south-eastern dome of the Greenwich Observatory was newly fitted up as a chronometer room; there is ample accommodation of tables for chronometers, a large and improved chronometer oven, and an exposed railed out-building for the cold-testing.

In the next following year Sir George sent detailed advice in instructions to captains of ships concerning the management of their chronometers. He directed them, (1) To keep the box or case containing the chronometer as far from any kind of moisture as possible: (2) To remove all moisture, inside or out, if any appears: (3) In moist climates to provide a baize-lining and cover for the case: (4) To be very careful in packing chronometers for transmission to Greenwich for repair.

The chronometers sent to Greenwich for testing, besides those belonging to the Royal Navy, have varied from 15 to 75 per annum for the last twenty years, averaging about 40 or 45. In 1873 the number was 41.

PNEUMATIC PROCESS OF SINKING PILES.

We extract from Van Nostrand's "Engineering Magazine," the following paper by John W. Glenn, C.E., who referring to the period of the Civil War in the United States in 1862, says:—"Then a Lieutenant of Engineers, I was assigned by General Leadbetter, Chief Engineer, to the charge of the outer line of water defences of Mobile Bay, which then consisted of only Forts Morgan and Gaines, both of which were incomplete and incapable of either offering serious opposition to a properly equipped fleet, or of maintaining a siege.

In the work to be then done so that, as far as practicable, Mobile Bay might be sealed against outsiders, that part of the line which presented apparently the greatest difficulties, was the middle ground between Forts Morgan and Gaines, beginning on the west side of the ship channel, thence to Fort Gaines, about two miles.

On this middle ground was an average depth of about 8 ft. of water, with a mean rise and fall of the tide of about 18 in.

This depth of water was sufficient to allow formidable gunboats to enter the bay, to which the two forts, being three miles apart, could offer little opposition, unless the vessels could be retained under fire a sufficient time to give the gunners of the forts their range, and make their fire effective.

The only method my superiors in rank then would consider was obstruction, and as the place to be obstructed was the outlet to that great bay, exposed to every swell of the Gulf of Mexico, through which the tides swept with a current of about three miles per hour, they were sceptical as to the practicability of almost any method, and at one time they had adopted the policy of quietly removing the munitions and surplus guns, reducing the garrisons to a minimum, merely to keep up a show of resistance.

After making a careful examination of the middle ground, I found it for a depth of over 20 ft., except near Fort Gaines, to be a deposit of sand, such as is common to the Gulf coast.

The violence of the storms, insufficiency of the sand as holding ground for anchorage, and the scour it was liable to, rendered chain-booms, cribs, and all usual methods of obstructing, out of the question.

As the bottoms of all war vessels then afloat were wood, it occurred to me that if ten rows of sawyers, none less than 18 in. in diameter, 10 ft. apart in each row, the sawyers of one row opposite the intervals of the next, were planted in that sand, not less than 12 ft. deep nor more than 20 ft., and then sawed off below the water so as to leave the stumps projecting above the bottom alternately 3 ft. and 4 ft., that if a vessel was to endeavour to drive its way through the ten rows, it would find itself "piled up" on the stumps with perhaps one or more through the bottom, or, in case of the forcible removal of the sawyers being attempted, the time required would be sufficient to enable the gunners of the forts to disable the vessel attempting it.

At the time, and considering the great width and depth of the ship channel next to Fort Morgan, it was believed that the displacement of water, and opposition to currents offered by the sawyers, would not produce observable results, but the Pelican Island channel, next to Fort Gaines, was, after the sawyers were planted, found to have scoured nearly 2 ft. deeper.

Owing to the attacks of the "teredo navalis," the sawyers would not have constituted an obstruction over one year, but when the limit of usefulness of one system was reached, another could be planted.

I submitted my views, together with the description of the manner of planting the sawyers by pneumatic pressure, and, in order to carry on the work expeditiously, asked for two steamers—the two steam fire engines of the city of Mobile, with complements of firemen, teams, and labourers, to procure the sawyers from Dauphine Island, adjacent to the work.

The steamers Dick Keys and Natchez were selected. Amidships, and just after the boilers on each steamer, a steam fire engine was placed, and bolted to the deck.

The steam-chest of the steam fire-engine was connected directly with the boilers of the vessel by an inch pipe, and communication with its own boiler broken.

Small shears were erected amidships, which led outboard sufficient to clear the vessel. From their head was suspended five pulley blocks and falls, for handling the sawyers.

About 50 ft. of hose and an ordinary $1\frac{1}{4}$ in. fire nozzle were attached to the air chamber, while the suction hose was passed out into the sea water. Each steamer would take on deck from twenty to fifty sawyers, varying from 18 to 30 in. in diameter, generally; though in one instance one of 48 in. in diameter was planted, and a great many between that and 30 in.

The ebb tide, at its greatest velocity, was selected as the time to make the beginning, and the Natchez was brought to anchor on the ground with about 100 fathoms of chain out and a kedge off her starboard quarter, with about 50 fathoms of 5 in. hawser out.

A sawyer was now swung by it, head to the shears; at its lower end two iron staples were driven, in which the brass nozzle was placed, and from the point of the nozzle, and outside the staples, a strand of tarred yarn led to the hands of the director, who controlled the movements of the engine, &c. The sawyer now hung suspended from the shears; a sufficient number of men had hold of the falls to control the sawyer; the director had hold of the yarn, with which he kept the nozzle in the staples, and the engineer stood at the engine, ready to start it when directed.

By the after capstan the hawser was now heaved in sufficient to bring the steamer quartering to the current which brought the chain and hawser both taut for a minute, perhaps. The instant the vessel settled, the steam fire-engine was started, and as soon as a stream of water began to flow through the nozzle, the sawyer was lowered and settled in the sand at the rate of about one foot per second. When the requisite depth was attained, the director let go the yarn, seized the hose and pulled its nozzle; the engine was stopped, and by this time the sand had settled to within 2 ft. of its original surface, and the sawyer was immovable.

After the first five sawyers were planted the steamers were moored to them, and, guided by them, moved ahead in the line of the work. After the first day or two the men became so adept that the work progressed very rapidly, even when there was a light swell on.

Over 5,000 sawyers were in that manner planted, when I was transferred to more important duties in the field.

The machinery and arrangements were the best obtainable in a country then cut off from the balance of the world; not by any means the best, with time and abundant resources for preparation.

The application of pneumatic pressure to sea-coast work first took definite shape with me in 1853, and was first applied by me in 1855, and I expect, eventually, to see it become a leading feature in preparation and giving fixedness to jetties, which must ultimately exercise great influence upon the shallow entrances to our Gulf harbours, the prominent features of which are this same sand."

THE VANILLA.[1]

THE vanilla is remarkable for its climbing habit, which is not common among orchids. There are several species, most of which are natives of the hot and damp regions of South and Central America; the genus is also represented in tropical Asia and Africa. The stems climb to the height of twenty or thirty feet, twining round the trunks of trees, and throwing out a profusion of aërial roots, some of which eventually reach the ground, as is the case with the banyan, while others float in the air. The leaves are thick and fleshy, as also are the greenish-white flowers. The important part of the plant, however, is the pod, which, in some of the species, is an article of commerce, and yields the delicious flavouring which is so well known. Some little uncertainty exists as to which of the species produces the most valuable fruit. It appears, that *V. planifolia* and *V. aromatica* are the most important, although *V. guianensis*, *V. palmarum*, and *V. pompona* also yield some of the vanilla of commerce. The pods as imported are narrow and flattened, from five to ten inches long, and of a dark brown colour; they are pulpy within, and contain a great number of very small dark seeds.

A great part of the vanilla of commerce is brought from Mexico and Venezuela, and principally from Vera Cruz, whence, according to Humboldt, the value of the annual export in his time was $40,000. The cultivation is mainly carried on at Misantla, twenty-leagues north-west of Vera Cruz, the inhabitants of which are the only people in Venezuela who cultivate the plant. The growth is, indeed, extremely easy, as the ground requires no tilling: slips of the vanilla plant are set at the foot of a tree on the approach of the rainy season, and soon begin to spread up the trunk. The plantations are cleared once a year from weeds and undergrowth, and in the third year the plants bear fruit.

Five varieties are recognized by the growers. One, the vanille de cochon, is so called from emitting an offensive smell whilst drying. The harvest begins about December, when the fruit becomes yellowish-green. There are two ways of preparing it for the market. In one method the fruit is allowed to dry until the pod loses its green colour. Straw mats covered with woollen blankets are spread on the ground, and when these are warmed through the fruits are spread on them and exposed to the sun. After a time they are wrapped in blankets, and placed in boxes covered with cloths, after which they are again exposed. In about twelve hours the fruits should become of a coffee colour, but if they do not the process is repeated. After about two months' daily exposure they are tied up in bundles of fifty, and packed in tin boxes. Five qualities of vanilla pods are known: the best is *primiera*, the pods of which are twenty-four centimetres long, and proportionately thick. The second quality is called *chica prima*, the pods of which are shorter, and two count as one; the third, *sacate*, and the fourth, *vesacate*, are still smaller, four of the latter being reckoned for one; they are gathered before they are ripe. The fifth and poorest quality is called *basura;* the fruit is very small, spotted, and much cut or broken about.

The following is another method of preparing vanilla for the market: About 12,000 of the pods are strung together by their lower end, as near as possible to the footstalk; the whole are plunged for an instant into boiling water to blanch them; they are then hung up in the open air and exposed to the sun for a few hours. By some they are wrapt in woollen cloths to sweat. Next day they are lightly smeared with oil by means of a feather or the fingers, and are surrounded with oiled cotton to prevent the valves from opening. As they become dry, on inverting their upper end they discharge a viscid liquor from it, and they are pressed several times with oiled fingers to promote its flow. The dried pods, like the berries of pepper, change colour under the drying operation, grow brown, wrinkled, soft, and shrink to one-fourth of their original size. In this state they are touched a second time with oil, but very sparingly, because with too much oil they would lose some of the delicious perfume.

It appears somewhat remarkable that the cultivation of vanilla in the West Indies has not been largely undertaken, as it would be attended with but little difficulty, and would be a source of much profit to the inhabitants. But even in Caraccas and Guinea, where the plant grows profusely in a wild state, it is almost entirely neglected. In the highland of Bourbon, however, it has been cultivated with considerable success, and seven-and a half tons were exported from Réunion in 1871. At Liège it is grown on a small scale, to the value of 600 francs per annum; and a plant cultivated at Paris in 1840 attained the height of three yards, and yielded 117 pods, which ripened in twelve months. In England it has been in cultivation since 1759; fine examples may be seen in the tropical and economic houses at Kew. Mr. Ewing and Mr. E. Bennett grew the vanilla with considerable success at Osberton; the latter gathered no less than 300 ripe pods off a single plant in one season. He considers a temperature of from 50° to 70° to be most suitable for it. He found it necessary to effect fertilization by artificial means, the stigma being prevented from receiving the pollen of its own flower by the interposition of an organ called the retinaculum.

As the English-grown pods are very highly flavoured, it is possible that it might be practicable to grow it for economic purposes. The annual import of vanilla amounts to about 5 or 6 cwt.; its price varies very greatly, being sometimes as high as 125*s.* per pound, and at other times as low as 26*s.*

The chief use of the vanilla is in flavouring perfumery and confectionery, and especially chocolate. One pod is sufficient to flavour a pound and a half of chocolate, being ground with sugar for that purpose. The fragrance is said to act upon the system as an aromatic stimulant, exhilarating the mind, and increasing the energy of the animal system. It is occasionally employed on the Continent in cases of hysteria; and is used by the Spanish physicians in America as an antidote to poison and to the bite of venomous animals, as well as in other cases. A liquid used in Peru, where it is known as *Baume de vanille*, exudes from the open pods at perfect maturity. The fruits in time become covered with an efflorescence of fine needle-like crystals, which possess properties similar to those of benzoic acid; when viewed through a microscope with polarized light they are very beautiful objects.

De Menonville, who travelled to Guaxaca in 1777, thus describes his discovery of vanilla in that district. After various hindrances and disappointments he says:—"At length an Indian, with a hoe in his hand, made his appearance. 'Brother,' said I, holding out a dollar, 'show me some vanilla and this is yours.' He coolly bade me follow him, and advancing a few steps through the underwood into a thicket, in which were a number of trees, he immediately climbed up one, threw down to me two pods of vanilla perfectly ripe, and pointed out to me a branch on which several others were hanging yet green, together with two faded flowers. The form of the leaves, the fruit, the peculiar smell of the plant—everything convinced me it was the real vanilla, in everything corresponding with such as I had seen at Vera Cruz. All the trees of this little copse were covered with it. I saw a quantity of green fruit, but collected no more than six specimens of these, and four large pods which were ripe. I caused the Indian afterwards to part from the root some of the scions which had sprung up. These I tied well together, wrapping up the whole in the leaves of an arum, which at their base are three feet wide. After thus packing a faggot, which weighed upwards of 30 lbs., I placed it in my large sack, which I fastened on my horse. I was so well satisfied with my Indian, that besides what I promised him, I gave him two reals in addition. For his part, unwilling to be outdone in generosity, he ran to his hut, and brought me three other pods of vanilla."

The Chica Vanilla of Panama is yielded by another orchid, a species of Sobralia. The expressed juice of *V. claviculata*, a native of mountainous woods in the West Indies, is applied to recent wounds, and is hence called by the French in S. Domingo *Liane à blessures*. There is a species known as *zizpic* in Yucatan, which is a great ornament of the *cenotes* or subterranean water caverns of the country. These singular caverns are sometimes entirely subterranean, and are then of course without vegetation; frequently, however, they are more or less open at the top, when they are often of surpassing beauty on account of the luxuriant development of vegetable life which they contain. To these *cenotes* the few ferns of Yucatan are almost confined, and it is here that this vanilla attains perfection. The pods are occasionally taken to market at Valladolid, where they may be bought at an almost nominal price.

[1] From the "Gardener's Chronicle" for May 23, 1874.

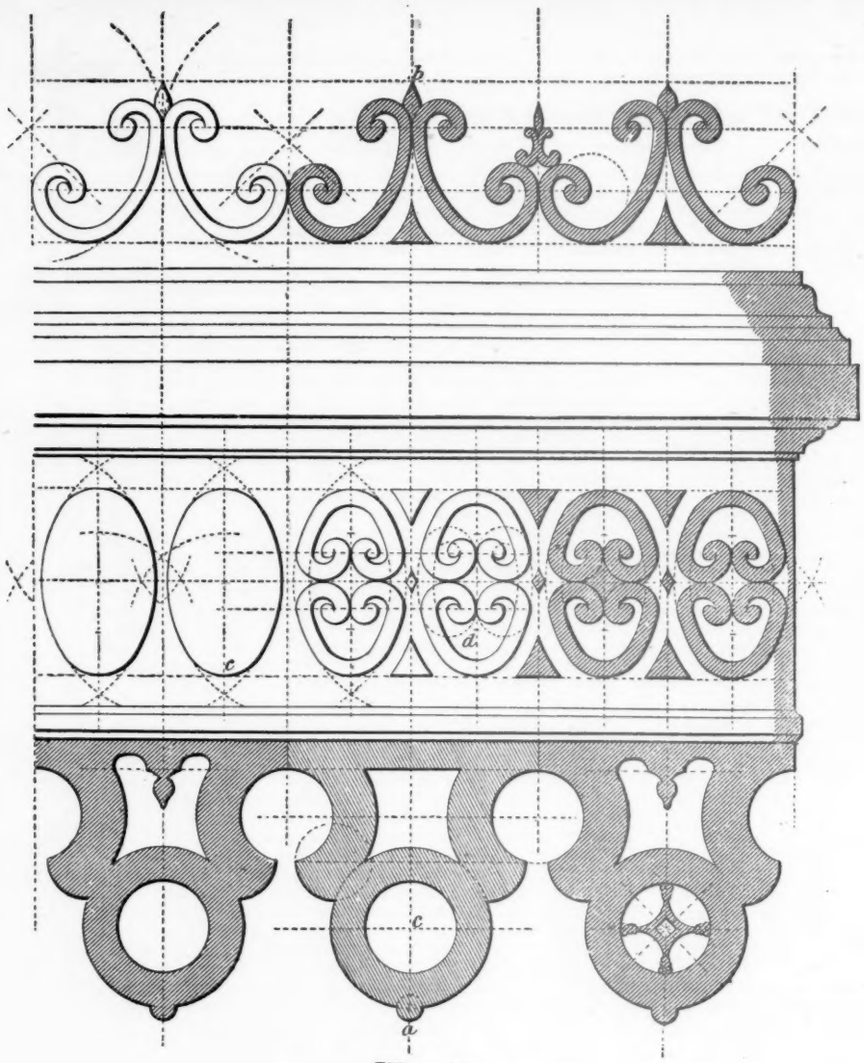


Fig. 390.

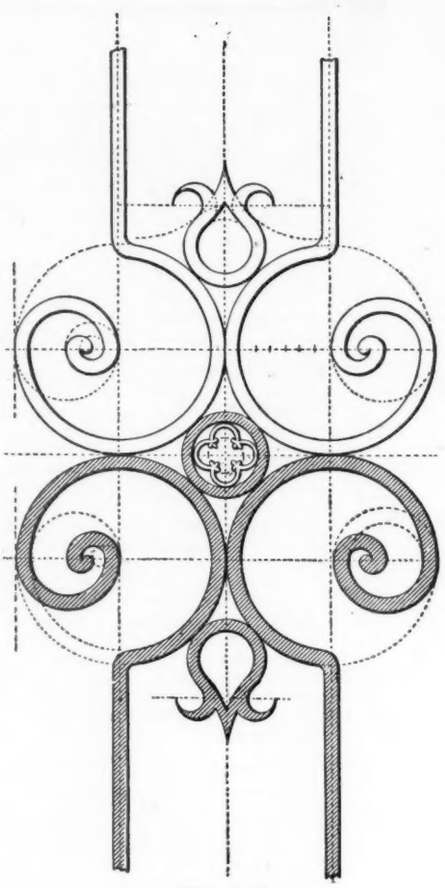


Fig. 398.

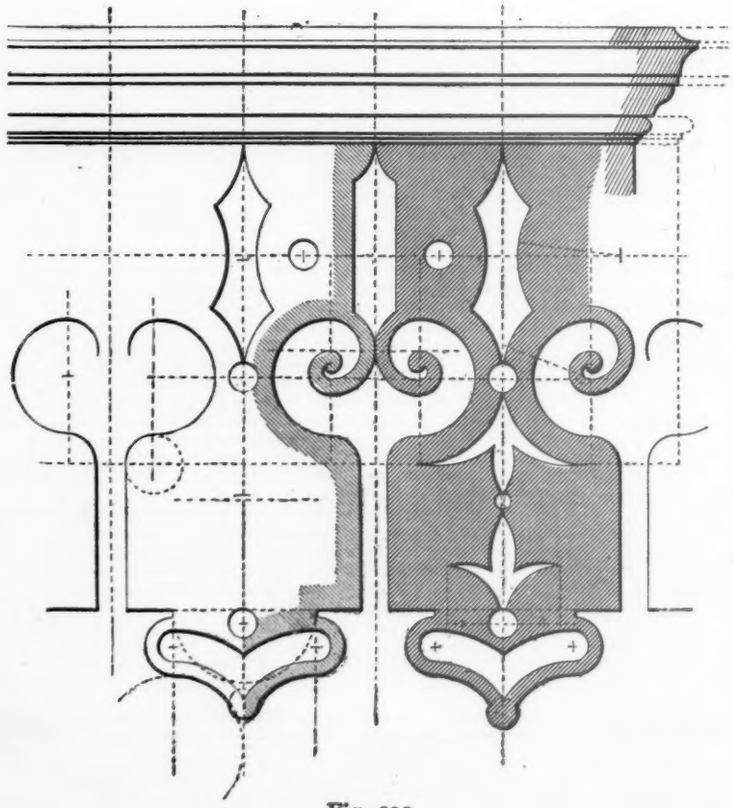


Fig. 391.

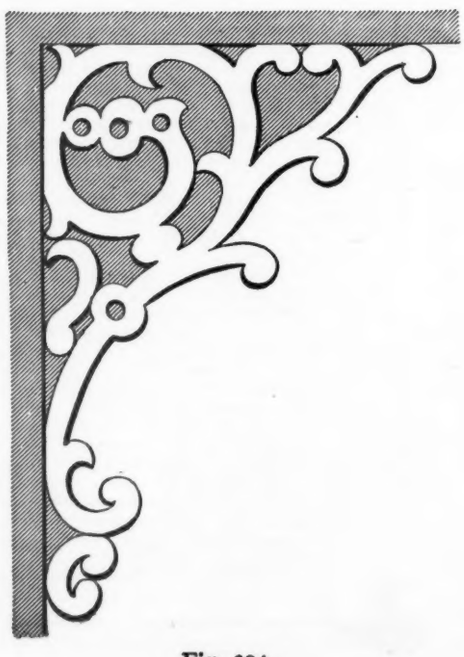


Fig. 394.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(77.)

DESIGNS for Cut-wood Work. — Continuing our designs in this department, we give in fig. 390 a design for a double eave, and in fig. 391 one for a single eave. In fig. 392 we give a design for the termination of the wood-work of a shed. In fig. 393 a design is given for a central terminal, and in fig. 394 for a bracket, and in fig. 395 a design for fret-work in two styles. In fig. 396 we give a design for an open summer house, or kiosk.

In figs. 397 to 399 we give various designs for ornamental iron-work. In fig. 400 we give in A, the front elevation of the lower part of a loo or side table, B being the side elevation. In fig. 401, A is an enlarged view of the central part in A, fig. 400, B being an alternative design for the central lower part in same figure.

CONDENSATION of Air and Steam by Cold Surfaces.—OSBORNE REYNOLDS has made many experiments on the rate of condensation of steam mixed with air, and draws the following conclusions :—

1. The presence of a small quantity of air in steam greatly retards its condensation on a cold surface; with pure steam there is no limit to the rate at which the steam will condense save the power of the surface to carry off the heat.

2. The rate of condensation diminishes rapidly and almost uniformly as the pressure of air increases from 2 to 10 per cent. of that of the steam, and then less and less rapidly until 30 per cent. is reached, after which the rate of condensation remains nearly constant.

3. By mixing air with steam before it is used, the condensation at the surface of a cylinder may be greatly diminished, and, consequently, the efficiency of the engine may be considerably increased.

4. The maximum effect (or nearly so) is obtained when the pressure due to the air is one-tenth that of the steam; *i.e.*, when 2 cubic feet of air at the atmospheric pressure and the average temperature 15°5 C., are mixed with each pound of steam. *Proceedings of the Royal Society, xxi.* 275.

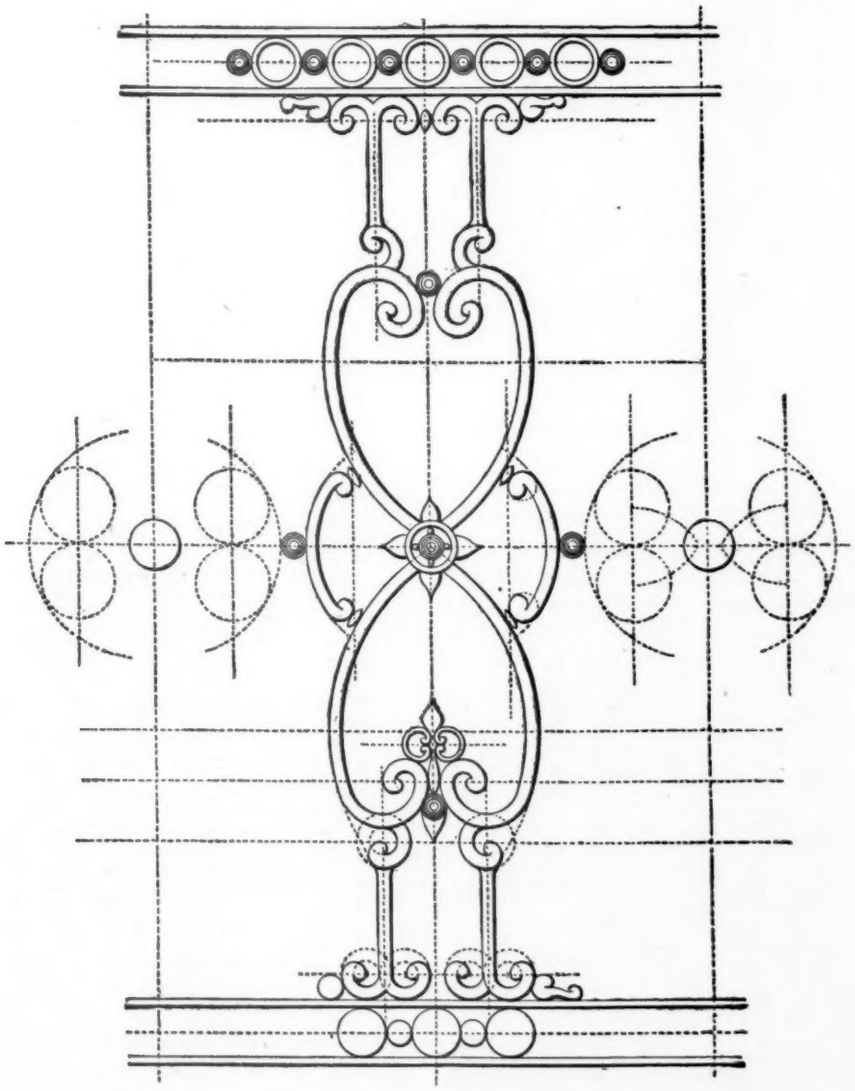


Fig. 397.

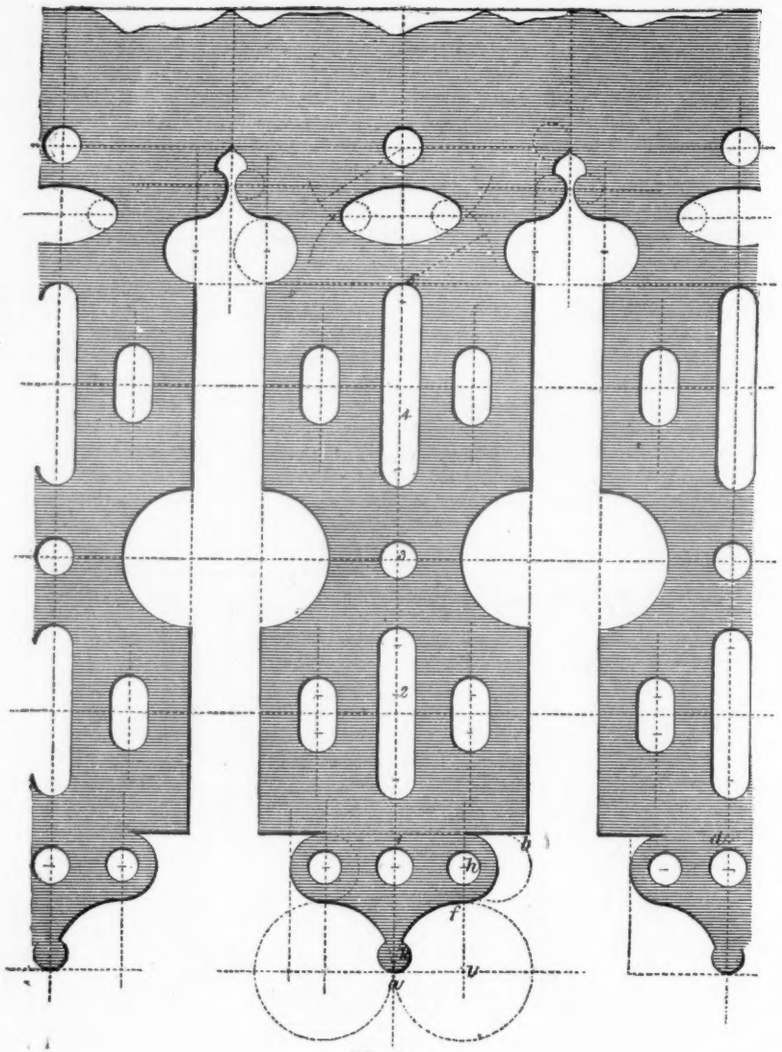


Fig. 392.

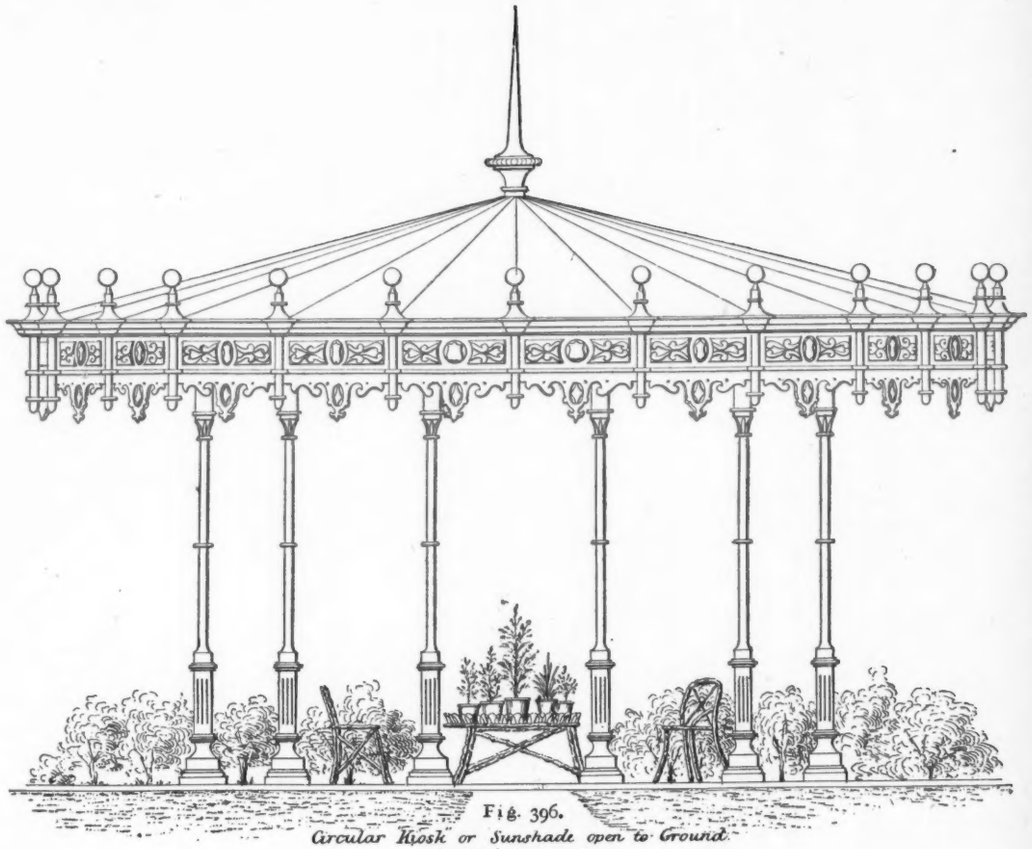


Fig. 396.
Circular Kiosk or Sunshade open to Ground.
Scale ½ Inch = 1 Foot

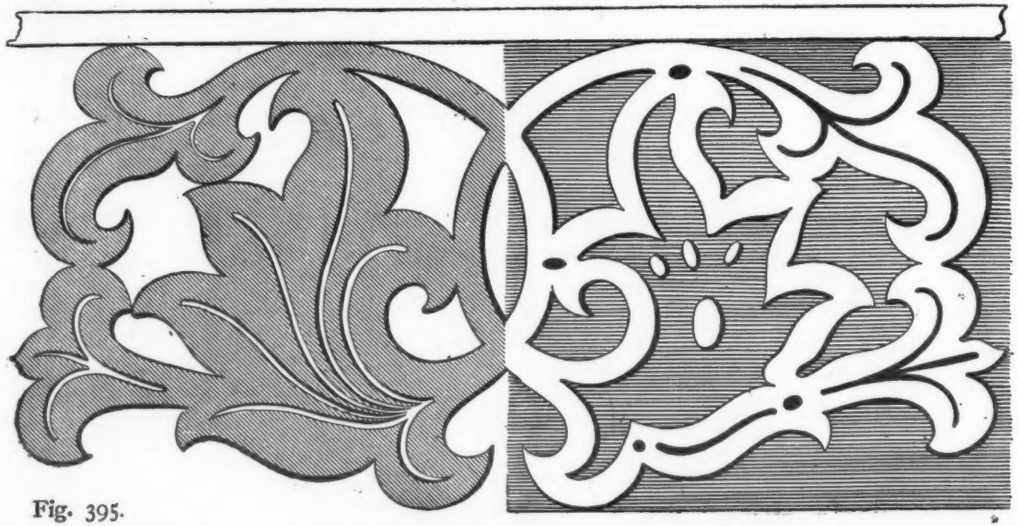


Fig. 395.

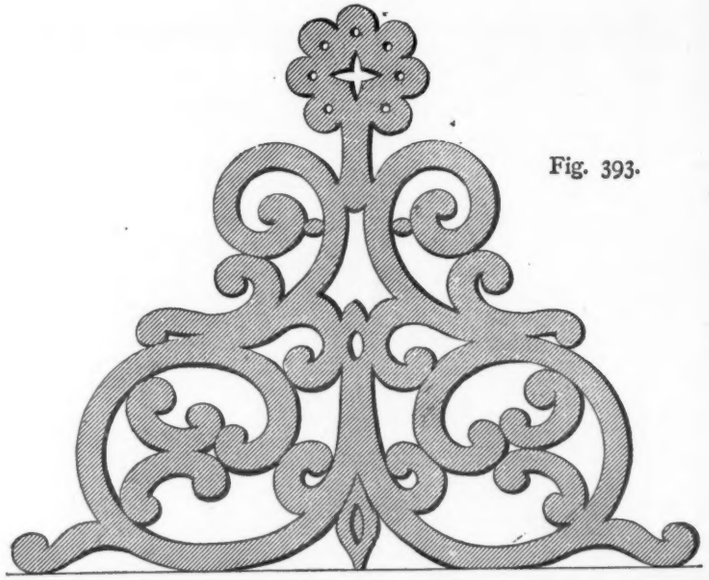
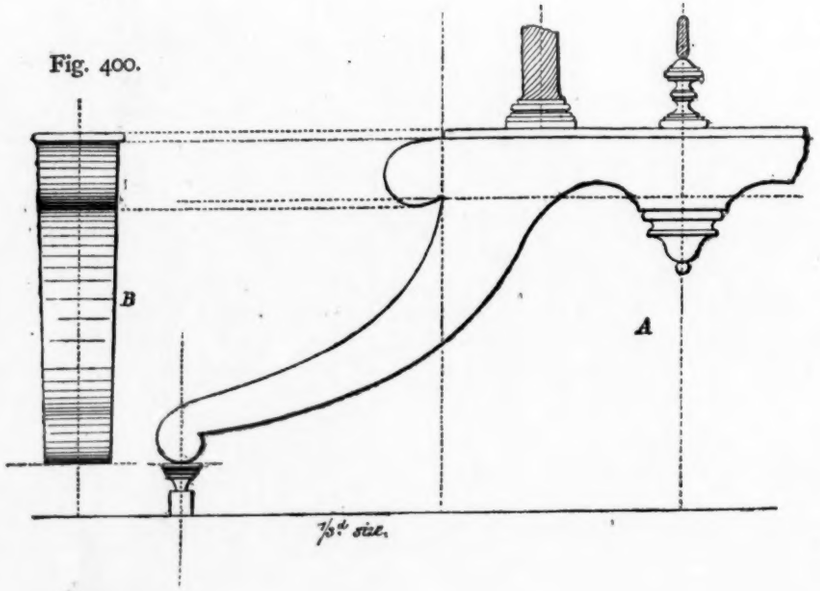


Fig. 393.

Fig. 400.



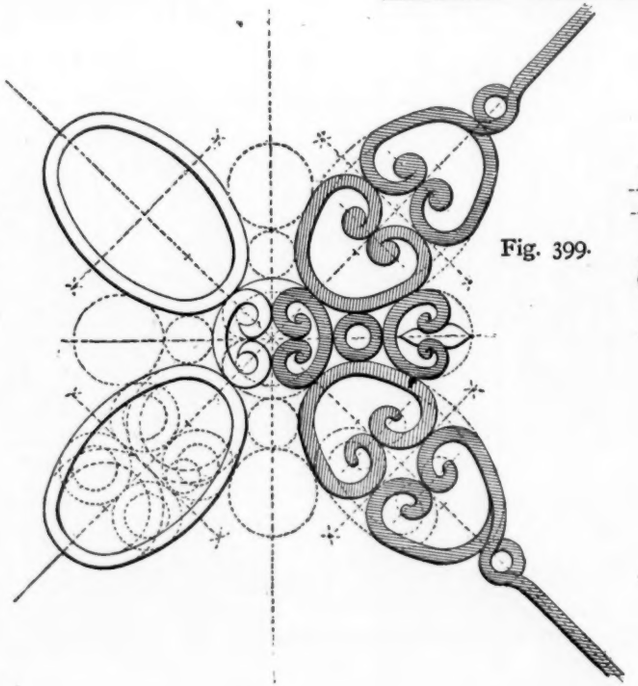


Fig. 399.

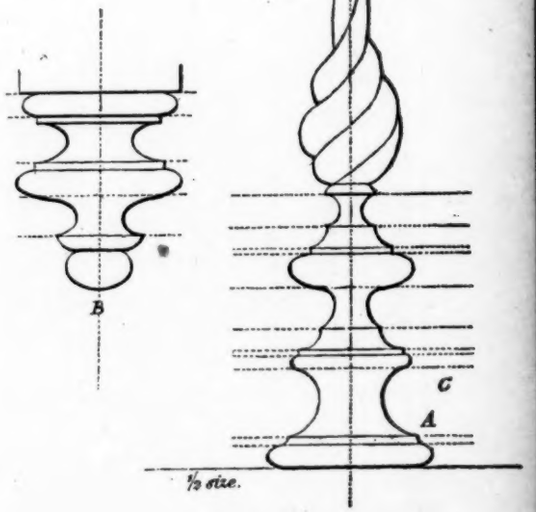


Fig. 401.

THE ALTITUDE OF BUILDINGS IN REFERENCE TO FIRE AND ITS EXTINCTION.

IT has been remarked that theatres are comparatively short-lived structures, and that their natural death is destruction by fire, the term of existence, from the opening night to that of cremation, rarely exceeding ninety years, and often being much less than this. The same sort of ending awaits almost every structure, great or small, and, as a natural consequence, it is usually assumed that care is taken by the architect to provide as far as possible against so treacherous and deadly a foe as fire. In view of recent remarks in the public prints on the question of Government rules to regulate the altitude of metropolitan buildings, it may be well to examine the question of architecture in its reference, not to fire prevention—for much has already been spoken and printed on fireproof construction—but to fire extinction. This matter is one to which little or no attention had been paid until the recent discussion on Captain Shaw's altitude limit of sixty-five feet, brought it into prominence; and now that it has been so brought forward, it ought to be carefully examined in all its bearings. Whether Captain Shaw's limit question be examined from his point of view or from a purely mercantile one, it will be found most suggestive. It is doubtful if the able captain of one of the best fire brigades in the world, when he first expressed his conviction, really himself saw the wide question he opened up for the consideration of all interested in the subject. On examination, it becomes at once apparent that the real philosophical interpretation of Captain Shaw's remark is that sufficient attention is not given by architects so to arrange buildings as to facilitate the labour and efforts of the fireman to extinguish fire, and it is probable that Captain Shaw himself, if the question were thus put to him, "If proper attention is given to the design of a proposed warehouse or other similar building to facilitate the fireman's strategy against the progress of fire, may not buildings be raised in safety to a greater height than sixty-five feet?" would say, "Certainly!" The limitation of height is a salvage insurance policy, neither more nor less: the lower the building the more limited the field of operation for the firemen and their machinery, the more rapid the arrest of the fire, and the greater the percentage of property saved. A building so many cubic yards in capacity, containing a certain quantity of burning material, requires so many cubic feet of water to extinguish the fire: all extra water thrown is a waste of water, labour and time.

Keeping to the division of the subject into two heads, and taking them in the order stated above, Captain Shaw's remark as interpreted to mean care to be taken in designing a building to facilitate the fireman's operations, the question comes, What can be done, and how is it to be accomplished? As to what can be done, reference must be made to the experience gathered from past disasters, every one of which contains a lesson, though such lessons have been but partially turned to account hitherto. The reasons for their being neglected are numerous and complex. The art of building habitations and warehouses has become stereotyped in all its branches, and architects are only, as it were, members of a cabinet. They are not perfectly free agents; anything they design out of the ordinary routine of the various trades sharing in the construction of the designs, tends to break up the harmony of the system, leads to expense, delay, and if the novelty be of any magnitude, difficulty is often encountered in carrying out the feature at all. Making allowance for this, however, the lessons learned could still be turned to better account than they are. Taking the application of water, for example, it is a known fact that water properly applied at close quarters is far more effectual than if the discharge takes place at a long range. At close quarters, the very momentum of the water beats out the fire, and the water is forced effectually into the charred surface of the material, which thus diminishes danger of reignition; the whole of the water, too, is available, no loss from evaporation or misdirection taking place. The captain of a fire brigade is in many respects, while battling with a fire, in a position analogous to that of a general fighting a pitched battle, and he needs to exercise quite as much tactical skill, and to possess quite as well disciplined an army. In great British towns the armies are all that can be desired, either for courage or for skill, but they work at a disadvantage. Nothing can be more primitive for the extinction of fire than the plan which in many cases has to be resorted to, of setting a man with a hose nozzle simply to direct a stream of water in through a window at haphazard, the stream or jet being necessarily often misdirected, and so long that by the time the water gets near the fire it is broken up into spray and easily evaporated, to the reduction of the quantity actually reaching the burning materials. It is hard to conceive any arrangement more adapted to aid combustion or defeat the efforts to extinguish it than that observable in any three or four storied buildings. The walls form a huge chimney shaft or furnace, the floors dividing it into compartments, which at once secure a plentiful admixture of the air so freely admitted through the windows and doors, and not alone admitted, but distributed equably throughout; while the floors, too, and in some degree the walls also, menace with a dreadful death those who enter to extinguish the flames. Under such circumstances, how can a fire brigade captain exercise any strategical skill to repel so swift and deadly an invader? The question then presents itself, What can be done in the way of first design to amend the evil? To answer this question reference may be made to the way the artillerist goes to work. A water jet is to all intents similar in its own function to a cannon shot in its; the artillerist knows the most effective range for his piece, and does all he can to bring his foe within its influence by placing the gun to the best advantage. His attempt to do this is much influenced by the nature of the ground, the cover protecting the gunners, &c.; and one of the qualities of a good general is to select a place for giving battle which will, from its conformation, suit the evolutions of his own troops and retard those of his adversary. In order to design a building which will facilitate extinction of a fire breaking out in it, two things must be aimed at—the one is to enable firemen to interpose every obstacle to the entrance of air to support combustion; the other is one which has never received attention, it is the providing certain standpoints from which water may be freely discharged into each apartment of the building. When an engineer is planning a fort, he carefully provides for the laying of the guns, so that each shall cover as great an extent of ground as possible. Well, then, all buildings of any but the smallest description should have what may be termed forts, constructed on such a principle that hose nozzles directed from them should command each apartment and its contents to the greatest advantage. The means of providing certain protected points in the walls of a building for this purpose requires some consideration, but so does any proposal for improvement. The object might possibly be attained thus: let the walls at selected points be pierced with holes large enough to admit of the entrance of the hose nozzle discharging the water, and to permit the fireman directing its operation to do so to the best advantage, yet so small that the fireman will be sheltered. Such holes may either be introduced as a feature in the general architecture, or else be built up with a thin filling of brick, easily knocked away when occasion arises. A step or platform, on which a person could stand, and at a suitable distance beneath each hole, would be necessary; but this could be arranged either in the form of an ornamental feature, or a pair of eye-bolts might be built in, to which could be hung a movable iron plate, large enough to afford standing-room for a man. A fireman standing thus could bring his water-jet to bear at close quarters, while he would be protected from much of the heat and smoke he now has to encounter if within the building, especially if he got to windward; and outside he would also be in comparative safety from falling roofs and floors. As to the danger from falling walls, even in this he would be, on the whole, safer outside than in. With the help of ladders, windows and mouldings, the sailor habits of most firemen enable them to reach places ordinarily inaccessible; therefore accessibility to these standpoints would prove no serious obstacle, if fairly and zealously dealt with. This scheme of what may be termed "water discharge points" by no means disturbs existing practices, it only supplements them, and it removes another and great difficulty, which is a well-known stumbling-block, viz., the obstruction to water discharges on burning material caused by iron division doors. These doors are sometimes of great value by confining fire to a particular apartment; on the other hand, both they and iron shutters often prevent any water being thrown on perhaps the very points where it would act to most advantage—true they also exclude the air, but that is a sorry compensation, because a plentiful supply reaches the flames in many cases from other sources. The real way to arrange matters is to leave the iron doors and windows, and to fit them in every "ope" in the building, and to provide other means, as indicated above, for the entrance of water. Iron shutters would not then, as at present, form a topic of difference between fire brigades and insurance companies, the former deprecating their introduction as being water obstacles, the latter to some extent insisting on their use as protection from adjacent fires. Both parties are right from their own stand-points, but wrong otherwise; the one wants to get water in to extinguish a fire inside, the other with equal wisdom seeks to prevent the entrance of fire, or of air to a fire already kindled. The scheme of "water discharge points" leaves the shutters to their proper use, and deprived of evil influence.

GEMS OF INDUSTRIAL ART.—DECORATIVE PAPER PANEL. STYLE OF LOUIS XVI. By M. Bezault.

The next point we arrive at is the water, its supply and delivery to the discharge nozzle. As regards its supply in the companies' mains, that forms an important question in itself, and one often discussed; it is one of some complexity and not easily solved, involving as it does the continuous supply question *versus* waste. This much, however, may be remarked here, that by far the larger percentage of fires occur at night, when people are in bed, and this is the time when, at least, there is most danger of loss of life, and at the same time least chance of water being wasted, consequently, during this portion of the twenty-four hours, the mains ought to be kept full. As to the conveyance of water from the engine to the nozzle, of course the hose is most suitable for conveying the water into closets and cupboards, &c., where the water from the discharge holes could not reach well; the hose, indeed, being the light cavalry of the army, just as the water discharge holes represent the big guns. The following suggestion is worth the attention of architects; within the thickness of the walls at such places as would suit the water holes best, permanent stand pipes of say four inches internal diameter ought to be built from ground to level of top floor, a branch "fire plug" being fitted outside—not within—the building at each floor. The fire engine could deliver the water into the pipe below, and a short hose above would carry the water to the delivery hole adjacent, this arrangement would save the wear and tear of so much valuable and costly leather hose, while from the straightness of the permanent stand pipe the water would suffer less loss of force, because of the diminished friction in the passage of the straight pipe as contrasted with a twisting and snake-like hose pipe. These schemes need a little working out but they will amply repay the time given to do so.

The second section of the text of this article is the mercantile aspect of Captain Shaw's proposal to limit height. This is a suggestion properly belonging to a man holding so arduous and responsible a part as he does. His business is to prevent the wholesale destruction of property by the flames, his business is to quench fire as speedily as possible, but singularly enough and as it happens unfortunately also, he has little voice in arranging for the prevention of fire; it is true that from time to time he has something to say on fireproof construction, but so far as his views go about what is referred to in the first section of this article, he is rarely consulted by either architect or insurance company. This is bad, these several departments ought to work into each other's hands more than they now do. A fire is not like a shipwreck of a vessel well insured, the disaster to the ship concerns alone her owners and crew and the underwriters; a fire in a densely populated and wealthy metropolis is a serious affair; an Englishman's house is his castle, and in an isolated country place he may set his kitchen chimney alight if he like, but it is quite another affair when the aforesaid castle is surrounded by those of other people; any occurrence of chimney burning in the latter case is most properly punished, because though the origin of a fire is often known, its place of ending is never so. This all points out how expedient it is that all the parties to building, fire insurance, and fire extinction, should work together, first to prevent the outbreak of fire, and secondly to limit its ravages where it does appear.

It is nearly certain, that however the height limit question may coincide with Captain Shaw's views and standpoint, it is, in any other way, fallacious; never was time of more value than at present, and each man of business forming as he does a centre round which his connection revolves, naturally desires to keep the circle of rotation as small as possible; the closer together men can work the less time there is wasted. It is common to hear people say land is so dear in the City of London that lofty piles of buildings must be reared on this or that site in order to compensate for the outlay in purchase or rental of the site; such persons overlook the fact, however, that the rent is high because such tall edifices can be built, and are indeed a sort of necessity to the rapid transaction of business; and it is not at all unlikely that the next generation will raise buildings more lofty than those now to be seen. Indeed, could the ascent of the wearisome stairs be improved upon by some other means of easy, safe and rapid ascent, an obstacle would be at once removed from the architect's path, and if in addition there was a roof gallery of iron added on, such galleries being universal and united by bridges over the streets, then one fifth floor man could go and see another—the houses of both being, say, eight stories high—by means of the roof gallery, with less stair labour than by going to the street level and ascending again. Let but Captain Shaw turn his motion about heights to account by making it the text of proceedings to induce architects to consult the fireman's views and the true relations of their respective departments, and he will have public feeling with him, but his proposition in its simply superficial aspect and meaning, is opposed to the exigences of business and the spirit of the age.

DOCK EXPANSION IN THE WEST.

II.

WE have spoken of the remarkable dock expansion that at the present time is being carried on in the various ports of the Bristol Channel. At Cardiff the progress is most marked, and the works are upon the largest scale. They differ from all the other works in that they are not done by companies or harbour trustees, but while they have the dimensions of public works, are due to private enterprise, and are managed by the trustees of a single nobleman. Not only in the Channel, but in the estuary waters of the Severn, works are actively proceeding. The Gloucester and Berkeley Canal is completing its docks just below Sharpness Point, where the river and canal navigation amalgamate. The only possible scheme for enlarging the dock accommodation of Bristol lies in the dockising of the Avon, where it meets the upper waters of the Channel at Avonmouth and Portishead. We are sorry to have to refer to the fact that the undertakings we have mentioned have been clouded with great disasters. It seems, however, to be a law in industrial history that great disasters are the precursors of great successes. The temporary Eddystone precedes the permanent Eddystone. The great works at the junction of the Avon and the Severn have been prostrated by the heavy tides of last winter. At Avonmouth the walls gave way owing to a bad foundation. The loss cannot be estimated at less than very many thousand pounds. The Gloucester Canal works have had still greater disasters. During their progress there was an immense collection of navvies at the town of Berkeley, and singularly enough, at the very town where Jenner made the immortal discovery that arms us against the small-pox, the small-pox broke out with deadly virulence. The accident which happened at Sharpness Point was so remarkable that we shall give some account of it. But for a providential concurrence of events a catastrophe might have ensued of a more appalling character than any of the sort which this country has ever experienced. The canal and dock might have been drained of their waters, the many vessels might have concussed, and it is a question whether the sides of the basin, in part supported by the water, might not have given way, and precipitated the immense warehouses on the banks. We put together, from the best local sources, an account of what happened on this memorable occasion, and also a statement of the present position of things. Whatever temporary discouragement may be caused by these misfortunes, the progress of the works will not be impeded. Before long there will be docks and harbour at Sharpness, the port and people of which will have a place of their own in the history of the extraordinary industrial development of our day.

The discharging dock, between which and the canal a junction was effected about the middle of March this year, is connected with the tidal basin by a lock about 320 ft. long. The walls of this lock are of immense strength, being 12 ft. thick at the base, with a varying width to 5 ft. at the top, and rest on solid beds of concrete. They are faced throughout with Forest stone, and the hollow quoins against which the gates have to fit are made of granite. Three pairs of gates are used in the lock; a pair at each end, and a third pair in the centre, so as to economise water in the entrance of small vessels. At the time of the accident the pair next the discharging dock had been completed, those at the tidal basin end were in a forward state, and the centre pair were being hung, one being already in position. The entrance gates also were not completed, and there was some work yet requiring to be done in the tidal basin. Hence it was necessary that, though the discharging dock might be filled with water and used, the lock and tidal basin must be kept dry; and there can be no doubt that this was the immediate cause of the disaster. It appears that about eight o'clock on a certain Saturday morning a crack about a quarter of an inch in width was noticed in the north wall of the lock, near the end next the discharging dock, which by mid-day had gradually increased, but not to any serious extent. About three o'clock, however, it began to widen considerably, and an hour later a tremendous crash, a rush of a torrent, and the ejection of a body of water to a great height, proclaimed a sad disaster. Mr. Harrison, the eminent engineer who has charge of the undertaking, was fortunately at hand, as well as Mr. Clegram, the engineer of the company. About sixty feet of the north wall of the lock had been bodily removed and then thrown down, a portion of the embankment had been washed away, and part of the remaining wall had been literally twisted out of position. The destruction of the wall involved also the destruction of one of the sluices used in equalizing the height of the water in the discharging dock

and the lock for the passage of vessels, and through this sluice the water rushed at a terrific rate into the dock and tidal basin, doing considerable damage. The lock-gate yet remaining to be hung was thrown down, though it is hoped that it is not damaged to any extent; and the wooden dam used at the entrance from the channel was partly broken away. Some idea of the force brought to bear upon the wall, which caused it to give way, may be gathered from the fact that an anchor stone, into which the iron-work supporting one of the lock-gates was fitted, and which weighed about ten tons, was broken asunder by the strain placed upon it by the falling wall, and the anchor itself was broken as if it were a rotten stick. As soon as it was discovered that the wall was giving way, a large iron caisson was taken to the bridge near the junction with the canal, and acted as a temporary dam. What otherwise might have been a great escape of water from the canal was thus obviated, and it only suffered a loss of a few feet. But for the use of this caisson, the most appalling consequences might have ensued. The consternation was great some fifteen miles off, when they saw the canal waters rapidly falling several feet, and could only conjecture how much lower it was likely to fall.

Whatever may have been its primary cause, there can be no doubt that the immediate cause of the wall giving way was a tremendous water pressure brought to bear upon it from behind. That this was so was apparent beyond doubt, but how the water got behind the wall has yet to be explained. It should be mentioned that, with a view to keep the lock and tidal basin as watertight as possible, and prevent the action of water upon the walls, a clay puddle trench, about 5 ft. wide, and reaching in depth to the solid rock, has been constructed from the end of the discharging dock round the lock and tidal basin to the entrance. Assuming, then, that water would not find its way through such a solid thickness of clay, the only reasonable conclusion to come to is that the water from the discharging basin must have percolated through unknown fissures in the rock, under the puddle trench, and thence to the wall. Adopting such a theory, it is easy to imagine the immense hydraulic force which brought itself to bear upon the foundation of the wall, and which, strong as it was, it was utterly unable to withstand.

When the accident happened, the lock was completed, with the exception of the finishing of the gates. The discharging dock and the graving dock were quite finished, and not much was left to be done in the way of dredging and other matters. The progress of the works will be watched with much interest.

We now turn to other parts of the Channel, and Swansea especially challenges attention. At Swansea no dock works are actually in progress, but very large schemes are in contemplation, and parliamentary powers have been obtained during the present session. Indeed, there has been a very considerable amount of legislation bearing reference to Swansea before the two Houses this session. To those who only know Swansea in its present smoky and commercial aspect, it requires a considerable stretch of the imagination to realize its former aspect as a fashionable bathing and watering-place. The promenades have been swallowed up by the docks, which occupy the very heart of the town; the north-east wind is always laden with copper fumes, which blast vegetation and threaten at times to suffocate the Swansea population. Yet the Bay of Swansea is as attractive as ever to visitors and tourists. That bay, with its graceful outline and mountainous shore, bears the strongest resemblance to the most beautiful of all bays, the Bay of Naples. The peninsula of Gower, which on the Swansea side is mixed up with coal, copper, and all kinds of commerce, as it trends westwards becomes one of the most peculiar and lovely districts of Wales. The inhabitants come from a Flemish stock, settled here by Henry I.; and these Gowerians still keep themselves very distinct from the Welsh, and preserve distinctive customs, dress, and language. The wonderful scenery, where bay after bay opens up pictures of beauty, has caused the migration of visitors to the Mumbles and the neighbourhood. Scenic loveliness has a directly material and commercial value at the present day, as testified by the history of all the watering-places that stud our shores. The chief employment at the Mumbles is about the oyster fishery; if only proper oyster-farming were introduced, there would be no limit to its capabilities. As it is, the Mumbles serve as a support to the oyster farms of France, when it might be an important industry of its own. It is not so very long ago since Swansea acquired such a distinctive and opposite character to the landscapes and seascapes of the peninsula. We are reminded that it is not a hundred years ago that the first great coal-owner, who substituted coal waggons for the old sacks and pack-horses employed to transport his coals to the quay, was threatened by the people with prosecution, "for turning the beer in their cellars sour, by the jolting of his heavy carts." Swansea, once called Abertawy,—a name now lapsing into oblivion,—now comes in as a very good second to Cardiff for the metropolitan supremacy of South Wales; and indeed the Swansea people would challenge the right of the Cardiffians to the first place.

It is, indeed, to the present injury of Swansea that the town is not on the main line of the Great Western, but is approached by a branch loop line. Swansea has not got all its real chances until this drawback is remedied. In any question of new docks the Great Western Railway will have a chief place. The Great Western has considerable legislation before Parliament this session, some of which touches Swansea, but unfortunately not in the earnestly-desired point of putting it upon the main line. The present Llandore viaduct looks perilous, and must be repellent to many. "All the way to Swansea from Llansamlet exhibits an unparalleled scene of desolation, to which a beautiful contrast is afforded by the distant hills at the head of the Swansea valley. The soil is naturally unfertile. The deleterious influence of the fluoric or arsenical acids from the copper works arrests the naturally stunted vegetation, so that there are no trees, and instead of grass a dry yellow sickly growth of chamomile barely covers the ground. To the traveller who crosses the Llandove bridge at night, the livid glow from the numerous chimneys, the rolling, fleecy white clouds of smoke which fill up the valley beneath him, the desolate-looking heaps of slag on either side, might well recall Dante's line—

'Lasciate ogni speranza, voi che entrate.'"

A few words will best here be said on the past and present of the port. We are mainly indebted to the "Cambrian" and the "Swansea Tide Table":—

Very considerable sums have been expended on its improvement, under the powers of various Acts of Parliament, commencing in 1791, succeeded by several others, until that of 1854, which consolidated and amended all the previous Acts, and constituted the present governing body of Harbour Trustees. Since 1854 Acts for the further improvement of the port have passed the Legislature, and the works therein contemplated executed; the result of all which is, that at a total cost of more than £600,000, Swansea Harbour now consists of an Outer Open Tidal Basin, called Fabian's Bay, of about 50 acres in extent; a South Dock of 13 acres, with Half-tide Basin of 5 acres, communicating with each other by a lock 300 ft. long, furnished with three pairs of gates 60 ft. wide, the entrance gates being 70 ft. wide; a north dock of 14 acres, with half-tide basin of 2¼ acres, communicating with each other by a lock 160 ft. long and 56 ft. wide, having at its southern or seaward entrance the large floating dock, formed in 1859, entrance gates 60 ft. wide, and at its northern end smaller locks, communicating respectively with the Swansea Canal and with the upper part of the river Tawe, navigable for nearly two miles for the smaller class of vessels which seek the copper and other works established on its banks. There is also within the piers a dry harbour, known as Port Tennant, constructed by Mr. Tennant in 1826, as the terminus of Tennant's Canal, which communicates with the town and Vale of Neath.

The trustees have also wisely expended large amounts in the establishment along the harbour of Sir William Armstrong's hydraulic appliances, by which the gates are opened, bridges swung, vessels hauled, ballast and other materials discharged, and coal loaded upon the most approved plans, with a celerity truly marvellous. Soon after the opening of the first dock, in 1851, the South Wales Railway completed its branch for the coal traffic, arriving principally along the Vale of Neath Railway, from the well known Aberdare and Merthyr coal fields. The following table of shipping frequenting the port shows what an impetus was given to its trade, especially the foreign, by the provision of floating accommodation, combined with railway facilities:—

	Coastwise.		Foreign.		Total Trade.	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.
1851	3,228	208,824	388	60,630	3,616	269,454
1855	3,676	249,276	1,223	195,441	4,899	444,717
1860	3,236	261,619	1,655	270,736	4,891	532,355
1865	3,297	298,045	2,188	405,323	5,485	703,368
1870	2,990	256,989	2,463	458,346	5,453	715,535
1871	2,787	239,875	2,316	479,911	5,103	719,786

In addition to the South Wales and Vale of Neath Railways' before mentioned, now forming a portion of the Great Western Railway system, Swansea is the port for the Swansea Vale Railway and the Swansea Canal, which traverse for 16 miles the Swansea Valley, which contains, in addition to the extensive copper, iron, tin-plate, and other metal works before alluded to, large collieries of all the various descriptions of coal, bituminous or binding, free-burning or steam, and anthracite or stone coal.

For a long time the Swansea people, satisfied with the very considerable progress of their port, have been very stationary. But the pressure from behind has been so great, the want of

greater space and deeper water has been so generally felt, that at last definite steps have been taken to forward the extension of the docks. Various schemes have been discussed at different times by the public, the Corporation, and the Harbour Trustees. We observe that at the meeting of the Swansea Harbour Trust conflicting views were held by the two members of the borough. Mr. Vivian, M.P., took a larger than any mere local view. It was not a mere question of where the dock could be best constructed, or even where it could be most cheaply constructed. The important enquiry was: "What site will afford the greatest facilities for trade; where is the trade most likely to come from; and where can it be conducted in the easiest and best possible manner?" The whole of the discussion is very interesting. In the Royal Institution of Swansea there is a large collection of pamphlets bearing on the history of the port, and much that has been lately said and written on this subject well deserves preservation.

After prolonged discussion the Swansea Harbour Trustees have applied for very extensive powers to make new docks, railways, and works. The site selected is that known as Fabian's Bay, which appeared to be best adapted for a deep-water dock and for the shipment of coal. This site best provides for the increase of the coal trade, which will principally come from the east. It is a feather to Cardiff that Mr. Vivian, when arguing for new docks at Fabian's Bay instead of an extension of the South Docks, said that "the only difference would be that by one course they would place themselves in the same position as that in which Cardiff now was—they would have a large, flourishing trade, with easy access to the docks, and would run with a flowing sheet, while in the other case they would be miserably cramped, and confined, as they had hitherto been." The fiscal difficulty, as usual, is the great difficulty. They have got their bill, but they have not got the money to carry out their bill. The Swansea docks have always paid their way, and whether dealing with a few hundreds as they did at first, or with hundreds of thousands as they do now, there has always been a modest surplus, and the credit of their paper has held good. The Swansea people hope that the new site will attract immense quantities of steam coal which are at present shipped elsewhere. Certainly it is the terminus of the Great Western line from the Aberdare and Merthyr districts. There is also abundance of land for shunting, sidings, and the erection of large works. The London and North Western will practically be shut out of Fabian's Bay, but could be accommodated on the South Dock. It was expected that a difficulty would arise from the fact that at present Fabian's Bay forms a harbour of refuge. The point however did not arise, and, more successful than the Bute Trustees, the scheme passed the parliamentary ordeal intact. Without doubt other schemes will eventually be carried out, such as the extension of the South Dock, and probably the conversion of all the waters into a floating harbour. We leave Swansea with the consciousness that great works and a great future are impending.

THE IRON PRODUCE OF THE WORLD.—The Official Report of the Vienna Exhibition gives the annual "output" of iron in the producing countries as follows: England (1871) 134,664,227 cwt.: Zollverein (German Bund) (1871) 33,296,042; France (1871) 23,620,000; Belgium (1871) 11,406,480; Austria (1871) 8,492,122; Russia (1871) 7,208,141; Sweden and Norway (1871) 6,138,347; Italy (1872) 1,474,180; Spain (1866) 1,474,180; Switzerland (1871) 150,000; total for Europe, 227,793,099. North America (1872) 46,900,000; South America, 100,000; Japan (1871) 187,000; other countries of Asia (approximated) 800,000; Africa, 500,000; Australia, 200,000; total for the world, 276,500,000 cwt. It appears from this statement that England produces more than one-half of the whole amount, North America, about one-fifth: France, about one-twelfth; and Belgium one twenty-fourth; these four constituting the great iron-producing countries of the globe.

BLUE CLAY FOR BOILER WALL.—A correspondent writing to "Leffel's Milling and Mechanical News" says:—"Our boiler wall was first laid up with lime and sand, and would crack. We took it down next the furnace twice. The second time we could not get lime and sand, and we took the blue clay from the well which we had dug, and made a rough mortar with it, full of lumps and stones. We put plenty in, and plastered the inside well; and after two months' steady hard work, firing with cobs, and cobs and coal, even the thin inside coat is on yet, and not a crack has shown itself in the brickwork, although we had steam up an hour after the bricks were laid. If this piece of experience will do anybody any good, they are welcome to it, as blue clay can always be had, while lime and sand are hard to get, and expensive, especially in this region—Central Illinois."

PRACTICAL PAPERS ON DESIGNING MACHINERY.

I.

MECHANICAL science is now so universally applied to the every-day affairs of life, it seems as though every person ought to be familiar with its laws and their practical application. This is the sort of argument that would occur to the mere superficial observer; those, however, who study Natural Philosophy as a pleasure in an amateur fashion, and still more, those who labour as professional mechanicians, know that even a slender acquaintance with mechanics is by no means a universal accomplishment. There never has been a period in the history of mechanical engineering, when books were more plentiful and cheap than they are now—never indeed were they so much so,—and the difficulty under which a student labours in this respect, is what our French neighbours would term an embarrassment of riches. It is, however, unfortunate for those who have to depend to any great extent on books, for information of any but the most abstractedly theoretical nature, that almost without exception, the scientific literature published now is so overladen with abstruse formula and technicalities, and assumes so extensive an amount of previous special knowledge of the subject treated of, on the part of the reader, that most of the books written on engineering subjects are of little or no practical value, —of little value to the student, because they assume so much to be known, of which he is ignorant, as to be incomprehensible to him, and yet fall so far short of advanced information, that those who possess the requisite knowledge assumed by the writers, find the books contain nothing not already familiar to them in a practical way, such as the book does not at all deal with. In this respect our American cousins certainly do better things than we can boast of, and we know of more than one American work on mechanical engineering, which contains more sound practical information on the details of practical engineering than any work published in Great Britain can boast of.

Students with us, when they go into the workshops, encounter daily and hourly certain difficulties and obstacles, and they search vainly such books as they can command, to find the commonest practical hint that will give them what is, in perhaps a slang parlance, known as a "wrinkle." The term is not exactly the most elegant, but it at once conveys a most practical meaning. The consequence is that a pupil, under existing circumstances, soon finds out that he will gain more genuine practical knowledge from a good workman in the shops in a week, than he ever would acquire in six years' study of books. There is no doubt an essential difference between reading of a certain piece of work, and how to do it, and actually seeing the same done; but still the gap between books and practice is wider than it need be. When Agrippa said to the great Apostle, that much learning had made him mad, it would almost seem that he foresaw the literature of the present day, for not a small portion of it seems to have been the offspring of the minds of those who, however sensible they might be in other respects, were incapable of conveying that knowledge which they professed a desire to convey to the minds of their readers. One of the most serious defects in the so-called rudimentary literature of the present day is a contempt of trifles. Possibly a portion of our readers will start and say—how so? well, one most serious defect exists in many elementary scientific works, and it is so apparently trivial, no notice has ever yet been taken of it. Hardly a scientific plate or diagram has got properly marked letters of reference on it; the letters are either misplaced, or else are altogether omitted; such misplacements and omissions matter little to the professional man, or even to the advanced student, but in nine cases out of ten they render that book useless, more than useless, to the elementary student. In the same loose fashion, again, we find formulæ incorrectly stated, and any man professing to write science for students must know that the correct statement of the terms of a formula is one of the most vital importance, consequently it is not enough for an author to write his symbols correctly in the first instance, but he must likewise read his proofs carefully.

The laws of mechanics rest so much on mathematics, they hang so completely on a sequence of reasoning, that a single defective link destroys the utility of any book or paper, however able its author may be.

At this present time there is scarcely a single work that treats in a practical way of the entire routine of a student of mechanical engineering; not one that takes him as a youth, helps him through the drawing-office, the forge, the foundry, the pattern-maker's, and the machine and erector's shops; that brings him step by step, as it were. from the crude idea in the inventor's

brain, and the pigs of metal in the foundry-yard,—along, step by step, to the finished machine, the very embodiment of the laws of mechanical science, as worked out to practical application by the brain and manual skill of man. Strange as it may appear, there is, as a fact, in but too many works on engineering, an absence of perception of how to fit the means to the end, even apart from defects of literature; the defect that the theoretical engineer labours under is that he fails to look at things in any but the purely scientific point of view; and yet Vauban, the great father of engineering—at least of "military," from which all civil engineering derives its origin—used to say, that "Common sense was the best engineer." And we may see this exemplified at any time; for practical pieces of work, which the mere savant can make nothing of, are well and ably accomplished by foremen of works, many of whom are ignorant of mathematics or of the laws of matter and motion.

The following papers on the practical designing of machinery are professedly for students, and if men advanced in the profession think them but elementary, well and good; but whoever writes to instruct, must remember that they only who are ignorant need an instructor, and be content to bow himself down to the understanding of those less learned in his specialty than he is himself.

The first thing that any student of mechanical science has to do is to make himself a perfect master of principles; a moderate acquaintance with some few practical rules may be afterwards formed, but nothing less than a thorough perception of principles will ever make a bold, large-minded engineer, or one capable of comprehending quickly and truly the real conditions of a particular problem. Nothing, on the other hand, so tends to cramp the mind and contract the views as the habit of working according to rules. Principles are to the engineer what the mariner's compass is to the navigator, while rules and formulæ answer to the lighthouses; the man who can work but by rule is like the timid sailor, who never loses sight of land, while he who depends on his knowledge of principles is fearless, knowing that Nature's laws never err, and that if he does not successfully apply her lessons, it is because he does not understand his instructor.

The two sets of laws in Natural Philosophy which more immediately demand the attention of the student, are those known as the laws of virtual velocities, on which depend the laws of strains, whether statical or dynamical. The second set are those which govern heat and work. These two groups of laws are the very key-stones of mechanical engineering.

We will take both in the order they are stated in above; and to begin, will explain that the term "virtual velocity" means the velocity or rate of motion existing in each portion of a moving body. Any body moving in a straight line has each particle of which it is constituted, moving at a uniform speed, but the moment it ceases to move thus, then each atom has a speed of its own, differing from that of any other atom not following directly in its track. Thus, if a cannon ball drop as a plummet to the ground without rotating on any point as well, each particle of its substance moves at equal speed, and we have what is in one sense, uniform motion. If, however, the ball moves in other than a straight line, then, in proportion as the constituent parts are nearer to or more remote from the inner line of the curve, so the speed of such part is less or greater, and we have, in one sense, a compound motion. Again, if we take a bar of wood or other material, and resting one end on the ground, move the other to and fro, we have the extremity on the ground almost at rest, while the other one moves more rapidly than does any other portion of the bar, and each section between the two has a proportionate intermediate velocity of its own. Each of these velocities, then, is termed the virtual velocity of that section of the bar.

In order to have the means of calculating the sizes and powers of engines and other machines, some units of measure are necessary, and hence the following are universally received and made use of by engineers. One pound weight raised one foot high is termed a unit of work, and is technically called a "foot-pound." It will be seen that this, though called a unit, contains two factors, viz., a distance or space, and a load or weight. It is impossible it should be otherwise, because work done means the transference of the load from one point to another.

The two terms of the unit of work are directly convertible, as it is termed. Thus, a pound raised ten feet means ten foot-pounds, and ten pounds raised one foot also means the same; or both factors may be subdivided into multiples of each other to bring out the result to ten, or fifty, or whatever other quantity may be involved in the question under consideration. For example, two pounds raised five feet, or two and a-half pounds raised four feet respectively, equal ten foot-pounds, or units of work done. From certain experiments made by him, Watt found that a reasonably strong horse harnessed to proper tackle and rope, taken over a large pulley wheel to a weight, suspended in a well or otherwise, could raise 33,000 lbs. one foot high in a minute, and this also has formed a unit or factor, ever since Watts's day, for determining or measuring the power, not alone of the steam, but of all other power-engines as well. If our readers will examine the above unit for a horse power, they will see that it is compounded of three factors, viz., the weight or load itself, the space it is moved through, and the time occupied. The same is the case with the foot-pound, the unit of time in both cases being a minute. Now, if the three factors are, as it is known they are, mutually convertible, then five pounds raised three feet high in a given time will exactly equal ten pounds raised seven feet in some certain space of time, and it is on a knowledge of this fundamental principle that almost all the calculations of the mechanical powers are based. Disturbing causes, such as friction, resistance of the air, or other surrounding body, have to be considered as disturbing influences, but they do not otherwise affect the great principle itself.

In considering the application of the laws of virtual velocities, the most simple practical contrivance in mechanics is the lever, because its action is so obvious, so self-apparent as hardly to need any explanation; therefore it may be used now to exemplify the convertibility of different statements of the unit of work; thus, taking a lever, say, 4 ft. in length and resting on a certain point, knife-edge or fulcrum, situated a foot from one extremity of it, then the arc or space, through which the longer portion would vibrate, will be just thrice that of the other or shorter end, while if loads are placed on the ends of the bar or lever, that on the short end must be thrice the amount of the load on the long portion; thus, then, we have, suppose 40 lbs. in the gross of the two loads, divided into 30 lbs. on the short, and 10 lbs. on the long lever, and if the lever is caused to vibrate so that the long arm traverse through an arc whose chord is 3 ft., the short arm has a chord of but 1 ft. Here, then, time must necessarily be a common factor or quantity for both loads, and we have 30 lbs. through 1 ft., or 30 ft. lbs.; the other being 10 lbs. through 3 ft.,

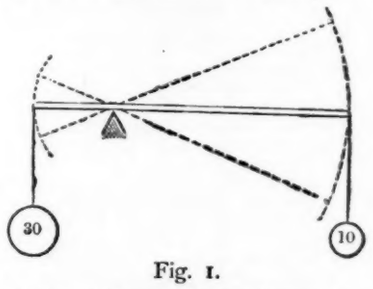


Fig. 1.

or again 30 ft. lbs. A glance at the little diagram, fig. 1, will show this clearly.

A point that is not as a rule brought with sufficient force before the student in most of the works that treat of mechanics, is, that all contrivances of whatever form are, one and all, simply *levers*. The wheel and axle, the lever shown in the sketch, the wedge and the screw, are all merely and simply levers, and their action rests simply on the principle of the difference of times or speeds for given loads. Let the student once properly master this fact and he will be saved a world of trouble and needless labour in making his calculations. We purposely avoid giving many diagrams, such as the pages of most books on mechanics are crowded with, simply because they are not needed and are apt to complicate needlessly what is in itself a simple affair. A combination of wheels, bell-cranks, screws, &c., are all, as grouped together, simply one single lever, and if a student would like to determine the point at which to place his fulcrum beneath his 4 ft. bar, he has but to ascertain the relative speeds at which the suspended weights at either end of the train, as it is technically called, of wheels and bell-cranks move, and this once determined, he can divide his lever in the two proper proportionate lengths, and the problem is solved.

To advance to the next step: we will take up the employment of steam as a motive power, and trace out how its force is calculated and applied to the performance of work; and the simplest method is to suppose a cylinder bolted to a beam across the roof of a workshop and fitted with a piston rod and lid as shown in fig. 2. We will say the cylinder is 6 in. in diameter, or about 28 in. area. Let a hook be turned on the end of the piston rod, and a load suspended on it. Now if steam of 50 lbs. pressure be admitted under the piston, we have—neglecting the area of the piston rod—28 × 50, or 1,400 lbs. on the piston; hence this load may be suspended on the hook, and will just balance the pressure on the piston. In this case the speed at which the piston and that at which the weight would move would be

equal, therefore pressure and load are the same in amount; but let a lever of any form, whether wheel and axle, or bar on fulcrum, &c., be interposed between the piston and the load, and we have a difference of speeds proportionate to the position of the fulcrum or of the relative diameters of the wheel and the axle.

It is as well that we should explain to our readers that the laws of mechanics are divided into two groups; the one being called Dynamics, or the laws governing matter in motion, and therefore the group most immediately involved in all questions of mechanical engineering; while the other group is called Statics, or the laws governing matter at rest, and more immediately relating to the direction and magnitude of strains; thus the two great branches of engineering—mechanical and civil—deal respectively with each group, but yet also having a respect for the influence of the other group of laws as well.

In considering the practical application of mechanical principles, the simplest sort of work we can invite the student to

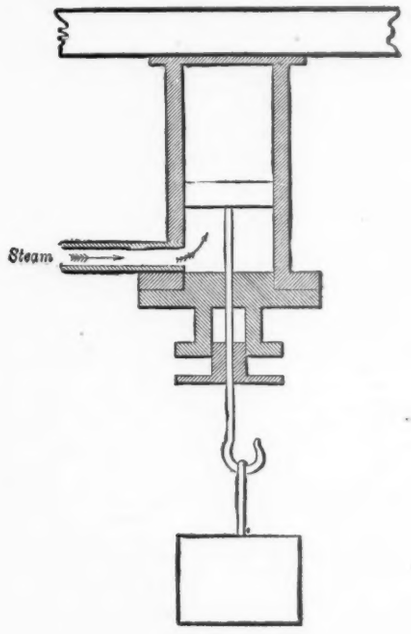


Fig. 2.

consider first is that of pumping water, and to place the matter in the most practical light before our readers we will suppose that a young man has served his articles—has passed, in a word, his professional curriculum, and has set up for himself in practice as a mechanical engineer. A client calls on him, and tells him he wants a forcing pump, with steam engine and boiler, erected, to raise water from a well 100 ft. deep, and to force it up into a tank on top of a tower or the roof of a bath-room; the bottom of the tank, when fitted, will be 30 ft. from the ground. The tank is to hold 1000 gallons, and the rate at which the water is to be pumped into it must be such as would fill it in one hour. The engine, boiler, pumps, and tank, and all pipes and fittings, must be drawn out, and a specification prepared, so that the work can be contracted for. Now, the young engineer will, in the first place, carefully note down the instructions he receives, for reference, according as he goes on with his work. He must then divide out his instructions and take each portion to itself, having, of course, at the same time consideration for the other portions. The first thing he has to determine is the load in dead weight, or, in other words, the number of foot pounds he has to lift. Let us, then, see what this comes to. The height, if we assume for the present that the tank is to be not more than 5 ft. deep, will equal 100 + 30 + 5, or 135 ft. Next for the weight in pounds. A 2 in. pipe—that is, a pipe 2 in. diameter in the bore—will be amply large; and to determine the power of the engine statically—that is, its power just to balance the load of the water—we must, of course, ascertain the weight of the quantity of water that a pipe 2 in. in diameter and 135 ft. long will contain. A pipe 2 in. in diameter is 3·14 in. in area, and then $\frac{135 \times 12 \times 3{\cdot}14}{1728}$ equals in round numbers 3 cubic feet of water; the factor 12 is to bring 135 to inches, and, of course, the total cubic inches divided by 1728 brings this to cubic feet. Now, a cubic foot of water weighs 62½ lbs., and also equals 6·25 gallons. To arrive at the actual horse-power of the engine required to fill the tank in the time specified, we must weigh all the water necessary to fill the tank, that is, 1000 gallons; a gallon weighs 10 lbs.; hence there is 10,000 lbs. to lift 135 ft. high in 60 minutes; therefore $\frac{10{,}000 \times 135}{60}$ will equal the number of foot pounds, and amounts to 22,500.

Now, we have already seen that one actual horse-power is equal to 33,000 foot pounds, so that to fill the tank in the time about two-thirds of a horse-power would suffice. This would give too small an engine to be of any practical service to our readers; therefore we will assume that the tank, instead of containing 1,000, will contain 10,000 gallons; consequently we want ten times two-thirds, or about, say, seven actual horse-power in our pumping engine. About 30 per cent. of power must be added to this for loss by leakage, friction, and other sources of waste. An engine of six nominal horse-power will work to nine actual very easily, so we may take it that a six-horse nominal will be powerful enough. A rough general rule for small engines is to give an inch of cylinder diameter for each nominal horse-power; so this engine will have a 6 in. cylinder; then 8 in. stroke will be a nice proportion of stroke to diameter.

We now have to determine the piston speed or number of revolutions of the engine, and to do this must find the velocity of the water; but before doing so the load or pressure of steam on the piston must be determined. A fair pressure for the boiler of this engine will be 50 lbs. per square inch, and allowing for some degree of expansion in the cylinder; loss from friction of the steam passing through the pipe; condensation from radiation; and for other sources of loss, about 40 lbs. in the cylinder, of average pressure per square inch, will be a fair estimate. Now the number of square inches in a piston 6″ diameter is 28·27, therefore 28·27 × 40 = 1130·80 lbs. The number of foot lbs. against the piston, or, so to speak, of the other end of the lever, is 22,500 × 10, because we have increased the tank contents tenfold, so we have 225,000 foot lbs. We have shown that speed and load are convertible terms, therefore to balance 225,000 moving through one foot, we must move the piston load of 1130·80 through such a number of feet as will multiply 1130 up equal to 225,000; to find this number we have but to divide 225,000 by 1130, or neglecting the decimal ·8, may say 1131; the quotient will be the piston speed, and equals in round figures 200 feet. Now the stroke is 8 inches or ⅔rds of a foot, and the piston moves twice in the cylinder for every revolution: so we have 200 × 12″ divided by 16″, which equals 150 as the number of revolutions of the crank shaft of this engine.

JARRE'S Power Pump.—The hydro-pneumatic pump of M. Jarre, for the transmission of power to a considerable distance, is the subject of a report by M. Haton to the Société d'Encouragement of Paris. The problem of transmitting power over long distances full of obstacles is undoubtedly not an easy one, and M. Jarre avails himself of compressed air for the purpose, and acts directly on the water without the aid of a piston. The pressure in the air conduit being subject to little variation, and resulting from the action of the force-pump, which is placed at a long distance from the source to be drawn from, a special arrangement was necessary to work the valves of injection and emission.

M. Jarre has adopted an intermittent fountain. An oscillating beam alternately opens and closes the way through which the compressed air finds its way to the surface of the water to be raised, according to the variations of weight in two movable parts of the apparatus, when in air and when immersed in water, that is to say, when the level of the water rises or falls. The action of the compressed air thus follows closely the movement of the water, and the pump continues its action so long as the pressure of the air is sufficient.

Several pumps of this kind have worked with success for two years at the Ornans Works, of which M. Jarre is directing engineer. It is admitted that there is a disadvantage in causing the air to act directly on the water, because the effective pressure is thus limited to the fixed pressure of the ascending column of the liquid, and by any loss in the conduits; but this objection is compensated by the special advantages of the pump in certain cases. Thus, one of them is placed at the distance of nearly 500 ft. from the motor, and the compressed air reaches it through a tube only four-fifths of an inch in diameter, and having twenty-eight heads at right angles. The water raised, which amounts to 18 gallons per minute, is conducted through a pipe of 1¼ in. in diameter, with nine right-angle bends, and two stopcocks.

A FEW NOTES ON MINES AND MINING IN HUNGARY.

[*Concluded from "Practical Magazine," No.* 19, 1874.]

THE mining region next in importance to that described in previous numbers of this magazine is that of the Banat. A somewhat exhaustive account of it, especially from a geological point of view, appeared a few years ago in the "Annales des Mines," that excellent periodical published under the auspices of the French Minister of Public Works. The memoir is from the pen of M. Castel, and we give the substance of it, with additions from other sources, in the here-following description.

The metalliferous strata of the Banat are bound together by a syenitic elevation situated north of that part of the Danube which separates Servia from the Banat. The syenite is not everywhere visible; it appears in the form of elongated masses in the general direction of the elevation only in four principal places which correspond with the mining centres of Moldova in the south, Szászka and Oravicza in the centre, and Dognácska in the north.

This syenitic line cuts several different formations, upheaving and metamorphosing them, notably among them the Jura chalk, the greensand, and the mica schists, whilst the tertiary miocene leans against the syenite in horizontal layers.

The period of elevation is thus to be fixed between the greensand and the miocene formations.

Along this syenitic line exists another much more salient elevation, stretching in a north-eastern direction. This latter has likewise upheaved the Jurassic formation, and the greensand, and produced all over the breadth of the Banat several parallel and well-pronounced faults, one of which brings to the surface the layer of combustible minerals at Steyerdorf and Domau. To judge from the aspect in which the strata upheaved by this great movement present themselves when meeting with syenite, it becomes evident that the latter is of an older date.

Where the syenite traverses the other formations it has produced remarkable metamorphic effects; thus it has transformed the Jurassic and greensand chalks into a large grained marble, occasionally of very fine appearance, and into a siliceous limestone.

In general there is no direct contact between the syenite and the traversed strata; in many cases, especially where the formation is chiefly chalk, a peculiar, in constitution and extent, variable rock exists between the two; this rock owes its origin to the geological phenomena which accompanied and followed the eruption. It is, no matter what its nature be, everywhere designated as "gangue," and it is this which contains the metallic deposits.

The presence of the metalliferous gangue is moreover intimately bound up with that of the chalk; where only the schistes touch the syenite, there the gangue and its metalliferous contents are absent, except in a few rare cases.

The nature of the gangue is, as already mentioned, variable, and so is that of the metals to be met with in them. The mineral which, besides the metamorphic limestone, the quartz, and the felspar, appears most abundantly distributed, is the garnet, both in the form of rock, and in a crystallized state, which is more or less charged with iron peroxide.

These four minerals constitute in general for themselves the rock of the gangue between the syenite and the limestone; the neighbourhood of the micaceous schists has often the effect to introduce there other elements, such as tremolite and amphibolic hornblene, both almost always in a fibrous and radiated state.

The metallic substances enclosed in the gangue are very differing, and it appears extremely difficult to express by any precise law the relations between their layers and the formations enclosing these latter, or between the constitution of the metallic minerals and the nature of the gangue. The existence of argentiferous lead minerals, and of rich copper ores, seems to stand in a certain relation to the presence of tremolite, whilst the prevalence of garnet in the gangue accompanies almost without distinction the oxydulated iron, the iron pyrites more or less charged with copper, and the cuprous pyrites.

A common feature of all strata, with which we are here concerned, is the almost complete absence of veins. The metallic substances occur in the gangue in columns, or in more or less elongated masses. The necessary result of such a distribution of the metallic substances is, that their search and exploiting is rather uncertain and subject to no definite conditions, such as exist with regard to the working of veins. The miners are guided in their search only by some empirical principles, based, it is true, on observation, but still void of any such absolute certainty, as that the metallic layers of a certain district incline chiefly to the neighbourhood of, or are in contact with a lode, and that the richest layers correspond to the excavations of the adjacent limestone mass. It follows from this further, that no just idea can be formed as to the extent of the metallic layers and their future working beyond what has already been ascertained through the mining operations.

Another necessary deduction from the above remarks, touching the geological formation of the metalliferous strata of the Banat is, that the ores, being found only in the gangue, and this ore being a product of the influence of the syenite on the limestone, will only be met with in the neighbourhood of the limestone, and since the depth of the latter is nowhere considerable, the amount of metalliferous substances can approximately be estimated.

It may also be assumed that a good many kinds of ores as yet unknown in the parts at present worked will, through the extension of the mining operations, be brought to light. But the future working of the Banat mines will be somewhat limited, more through the difficulties attending the surveying operations and the extraction of the metals than through an exhaustion of the layers.

The whole of this mining region is divided into four districts, of which the following four places are the centres: Moravicza-Dognácska, Oravicza-Csiklova, Szászka, and Moldova.

The distribution of the various metals and ores in these four districts will be alluded to further on, when the treatment of these ores will be described.

The mode of working the mine is simple enough. A little below the surface of the ground a horizontal cut is effected and broken in stages into a quarry, which later on serves as a road for the transport of the ores from the interior; from this quarry shafts are pushed in all directions, but care is taken to keep the floor of these shafts pretty much on a level with the main gallery. When the working of such a quarry is sufficiently advanced, and the opening of another level becomes necessary, a gallery, about twelve to twenty metres below the first, is pushed from the hillside as much as possible towards the centre of the metalliferous stratum. From the bottom of the higher gallery a shaft is sunk down into the lower one, and successively enlarged, in order to admit air and light to the lower level. In similar manner a third gallery is established, and so on, depending, of course, on the thickness of the ore-yielding stratum.

In some parts a bold attempt has been made to unite such successive strata of galleries into one gigantic quarry, in order to have easier access to the copper ores which seem there to be deposited in nest-like cavities; but the plan was ultimately abandoned as impracticable.

A somewhat curious, irregular mode of working is pursued in the southern division of the Szászka district, where cupric oxide enclosed in an argillaceous hematite is obtained. The layers containing these ores have been worked for more than a century; the workings always starting from the surface and penetrating gradually deeper, but never to any noteworthy depth. The miners work and have ever worked at their own risk, the proprietor contenting himself with buying from them the ores obtained, and they also work without any concert among themselves; a man usually digs a pit and explores from this in short galleries the neighbouring strata; when he fancies that the ground is exhausted, or that he could elsewhere work with greater advantage, he abandons the spot, which soon tumbles into ruins, to start his new pit. Where however the number of miners is great, the proprietor interferes in so far that he constructs some common gallery for the conveyance of the ores, and sees to the ventilating and pumping,—concerns which are above the means and powers of the isolated miners.

This system is called the *Raubbau* (from Raub—robbery, and Bau—construction, work), the name well indicating that the work is carried on solely with the view of the immediate remuneration, and with complete ignoring of future requirements or the idea of a methodic exhaustion of the ground.

Curiously enough, such abandoned pits are often after the lapse of a few years re-occupied by their former or some other workmen, and successfully worked, and such re-occupation is not unfrequently several times repeated. It is asserted that in those pits a kind of natural concentration takes place through the sandy masses being washed into them by the rain water. This explanation is rather difficult to be accepted, but it is given not merely by the native miners, but by the higher mining officials.

In the southern division of the district of Moldova the ore is so poor, that artificial washing for the purpose of concentrating

it must be resorted to; the results thereby obtained are most favourable.

In this same division of the district of Moldova is also the mine which supplies almost all the pyrites for the sulphuric acid factory at Moldova. The mine is situated in the Benedikter Gebirg, and is worked in two superposed galleries, at 22 metres distance from one another.

To each of the above-mentioned four mining centres correspond smelting and refining works for the treatment of the ores. The necessity of utilizing as much as possible the water power, and the difficulty of uniting into a single fall the water furnished by the valleys, which at the same time has also to serve for other industrial purposes, notably for flour-mills, has led to the construction, in each of those four mining districts, of several smelting stations, at distances of from 1 to 2 kilomètres from one another. This, of course, is connected with many disadvantages; it necessitates the useless transport of materials from one smelting station to another; it compels the keeping up of several coal and other stores; and it renders supervision very difficult.

It ought, however, to be remembered that these smelting works, dating from ancient times, have been erected one after another in the measure as the mining productions increased.

In spite of the dispersion, there nevertheless reigns in all manipulations the desired unity. In all the centres, the final operations are concentrated in one of the smelting huts, whilst the remaining stations are uniformly kept in work with preparing the ores for the final treatments in the finishing furnaces.

The same unity exists as much as possible in the whole of the Banat mines. It is self-understood that the ores extracted in each ore-mining centre are, with a few exceptions, subjected there to all those preliminary operations which aim at converting the ores into rich matt; for the transport of the ores from one smelting furnace to the other would entail expenses quite out of proportion to their value; but the final operations, which yield the products ready for the market, are concentrated in localities where ores of the same kind present themselves in the greatest abundance.

Thus the production of the non-argentiferous copper (rosette copper) is concentrated at Szászka, and that of the silver-bearing copper at Csiklova; the separation of silver from the last named sort of copper is effected at Moldova, where there is also a sulphuric acid manufactory; finally, the treatment of the lead ores, of the rich argentiferous substances, and the refining of the metallic silver, takes place at Dognácska.

We shall, in succession, review these various workings in the order just indicated.

The smelting station of Szászka, which furnishes the rosette-copper, receives all the ores extracted in its district; they may be divided into three distinct classes:—

1. Ores containing sulphur, as copper pyrites, purple copper ore, and some little copper sulphide, distributed in shape of small lumps in a gangue of garnet and amphibole mixed with limestone and quartz. These ores contain from 2 to 60 per cent. of copper, but the great average is 4 per cent. They are pure, and quite free from iron pyrites; and the chief drawback to a more remunerative working is the preponderance of the gangue.

2. Cupriferous iron pyrites, containing on the average 1 to 2 per cent. of copper; their gangue is garnet, associated with limestone and quartz. These ores are merely used as flux.

3. Oxides of copper, strongly intermixed with oxides of iron, and occurring in an argillaceous gangue; their average yield is 1½ per cent.

The relative proportion of these ores varies a good deal. A few years ago, the sulphurated ores and the oxygenated ores were each 50 per cent. of the total yield of the district, whilst several years anterior to this, the last-named ores predominated.

There are three separate smelting furnaces in the district of Szászka. The hydraulic strength for each of them is about 12-horse power; the blasts consist of simple square boxes of wood; and indeed all the utensils and apparatus are of rather primitive construction.

The above-named ores are brought unitedly into the crude smelting furnaces; the object of this first smelting is to collect the copper into a matt. In this operation, the quartz of the ores unites with the half-reduced iron oxides, the alumina and the lime to form a slag (usually a singulo-silicate of iron protoxide, lime, and alumina), whilst the sulphur of the pyrites seizes upon the copper, and forms with it the matt.

Sometimes quartz and blast-furnace slags are added to the charge, in order to facilitate its fusion. Occasionally the matt obtained is added to a succeeding charge, not so much for the purpose of enriching it, as for that of protecting the copper of the ores against passing into the slag, which happens the more easily as the copper is present in the state of oxide, and is as such brought, during the fusion, into contact with a large quantity of combined sulphur. At the same time the admixture of the matt to a new charge facilitates the collecting of the isolated molten drops of metallic copper.

As a rule, it is not intended to get in the first fusion a rich matt, for the presence of a large amount of silica is apt to bring notable quantities of copper into the slag, especially if the proportion of iron sulphide to copper is not strong enough.

The operation is carried out in an ordinary blast furnace, but of considerably smaller dimensions than that usually employed in iron works. A campaign lasts forty days at most, but is, as a rule, much shorter, thirteen to twenty days. The quantity of ores worked up averages from 8 to 10 tons in twenty-four hours.

A charge of 1,000 parts by weight of ores is made up as follows:—

Oxygenated and sulphurated ores from Szászka	815
Ores from Oravicza	44
Crude pyrites	114
Roasted pyrites	15
Different cupriferous materials	12
Ores, containing on the average 18·5 copper	1,000
Additions—	
Crude matts	155
Cuprous scrapings, &c.	13
Quartz	9
Slag from previous crude fusions	22
Total of charge	199

The yield of this charge is as follows:—

Matt with about 12½ per cent. of copper	147·5
Copper waste (to be added to a new charge)	13
Slags (estimated by difference)	1,038

The costs of the smelting of the ores stand for the ton:—

	s.	*d.*
9 kilogrammes of quartz	0	0¼
5·56 measures[1] of charcoal, at about 1*s.* 5*d.*	8	0¾
Wages and divers materials	2	10
Total (without the general mining expenses)	10	11

For the last ten years the productions have steadily improved. Attempts have been made to treat richer ores separately, and at once to transform them into raw metal; but the presence of some little arsenic in the ore, which then passes into the metal, and alters its qualities, compelled a return to the former mode, where the rich ores, alike with the poorer ores, are first converted into matts.

The matts obtained as above described, are submitted to roasting, and afterwards fused. The roasting takes place upon special hearths, usually open ones. The matt, broken into lumps of the size of an ordinary potatoe, is disposed in layers of 2 to 3 feet thickness upon heaps of wood.

The expenses of roasting a ton of matt come to:—

	s.	*d.*
Charcoal	0	3
Wood	5	0
Wages and divers materials	5	4
Total	10	7
Making for 1 cwt. of copper (about)	9	0

The next operation is the fusion of the roasted matt to reduce it to black copper. (The name is given on account of the dark colour, due to the presence of impurities, chiefly of sulphur.) The operation, which takes place in shaft furnaces of less size than those employed for the first crude fusion, completely reduces the cupric oxide, and partially also the iron oxide. There remains, however, sufficient sulphur in the mass to protect the copper against being dragged into the slag.

The charge for this second fusion is made up in the following manner,—

1,000 parts roasted matt, containing 13·7 per cent. copper		137
62	parts roasted thin matt, 52 per cent. copper	32
99	„ copper waste, with 26·2 „ „	26
126	„ quartz.	
184	„ slugs from crude fusions.	
Total, 1,471	„ with an amount of copper	195

[1] The measure for the charcoal is equal to about 10 cubic feet, and the weight of its contents, beechwood coal, is very nearly 1 cwt.

The yield is—

166	parts	black copper, with 95·2 per cent. copper . .	158
62	„	thin matt, „ 52 „ „ . .	32
53	„	copper waste, „ 11·6 „ „ . .	6
1,190	„	slags[1] (by difference).	
		Copper	196[2]

Costs of the operation per ton of crude fusion matt :—

	s.	d.
Roasting of 62 kilogrammes of thin matt . .	0	8
8·8 measures of charcoal . . . (about)	12	0
Wages and divers materials	3	0
Total	15	8

Making for 1 cwt. of copper contained in the crude matt, 11*s.*

The black copper, containing, as already stated, about 95 per cent. of pure metallic copper, is next submitted to refining. This operation is carried out either on a small hearth or in the so-called Hungarian furnace ; the latter is the more frequently used method, on account of greater cheapness, though it yields a copper of less purity, but which, nevertheless, is sufficiently good for being worked into cauldrons, stills, &c., at Csiklova. The first-named method is employed for producing the raw commercial copper, designated, on account of its light colour, rosette copper ; its price is at least 4*s.* higher for 1 cwt. than that of the ordinary copper, going by the name of "Spleisskupfer."

The Hungarian furnace used at Szászka has a circular bottom of about 2·5 metres diameter. The thickness of this bottom, which is formed of a mixture of decomposed refractory schists (seven parts) and clay, with a little quartz (half a part), is about 1 ft., and the height of the vault from the bottom is 1 metre.

There are two tuyères ; the one is placed near the fire-place, opposite the door by which the furnace is charged, the other about 18 in. further on. The first is horizontal, the second inclines very slightly towards the bottom. Their axes are so arranged that they intersect at the centre of the furnace, and both have the same width—2½ in. diameter. The fire-place, intended for the combustion of wood, is a little more than 6 ft. long, and about 2 ft. broad ; the grating is 12 in. below the bridge.

There are three receiving basins upon a grating outside the furnace, on the opposite side of the fire-place.

The refining takes place without the addition of foreign materials, simply by oxydation. The charge is about 2,500 lbs. avoirdupois, and each operation lasts from six to seven hours. At the beginning of every campaign twenty to twenty-four hours are required for the drying and heating of the furnace. One campaign consists of ten or twelve chargings.

The fusion lasts three hours, and at the end of the second hour the blasts are set to work.

The small hearth used for the production of the rosette copper is formed of an elliptic basin, of about 30 in. length and 24 to 26 in. width, and a cavity of about 9 in. depth. The semi-circular nozzle, diameter 7 in., advances 4 in. into the basin, with an incline of 8° to 12°.

A single charge consists of about 850 to 900 lbs. of black copper ; the operation lasts about six hours, and four to six operations complete a campaign.

A charge of 1,000 parts of black copper, containing 950 pure copper, to which about 13 parts of waste copper[3] are added, yields—

815 refined copper	815
381 rich slag, with about 40 per cent. of copper .	153
Total	968
Bonus of copper above the estimate . . .	5

The costs for every ton of black copper are—

	£	s.	d.
Charcoal	0	3	2
Wood	0	8	0
Wages and various materials . . .	0	12	9
Total	1	3	11

[1] A specimen of such a slag analysed gave the following figures:

Silica	38
Iron	52
Alumina	2
Copper	0·6
Lime }	7·4
Magnesia } . . .	
	100·00

[2] There is usually a larger yield in the operations than indicated by analysis in the laboratory.

[3] From spoilt castings, &c.

Making for every cwt. of copper contained in the black copper about 2*s.* 6*d.*

The above estimates refer to an operation in the Hungarian furnace. For a charge in the small hearth the following figures are given :

1,000 parts of black copper with	
94·5 per cent. of copper	945
10 parts of waste copper. . . .	10
Total	955
Yield,—	
733 parts of rosette copper . . .	733
883 „ „ rich slag with about 25 per cent. of copper	220
Total	953

Costs for the ton of black copper :

	s.	d.
Charcoal	20	0
Wages and various materials . .	14	6
Total . . .	£1	14 6

This sum apportioned to 1 cwt. copper contained in a ton of black copper is about 3*s.* 10*d.*

To these special expenses, mentioned for the preceding operations, must be added the general costs, which are by no means inconsiderable in proportion to the produced copper.

If we sum up the above given items of costs, we shall find that the total special expenses for converting ore into refined copper at the smelting works of Szászka are:

	s.	d.
Costs of crude smelting (for 1 cwt. of copper) .	10	11
„ roasting of the matts „ „ .	8	0
„ fusing the black copper „ „ .	11	0
„ refining in the Hungarian furnace „ .	2	6
„ general, of the works, calculated on a production of about 1350 cwt. . . .	16	0
	£1	17 6

Reducing likewise the costs of crude smelting for 1 cwt. of copper the total expenses demanded by the complete working up of the ores are found to be about £4 10*s.* for 1 cwt. of copper.

The mines in the district of Moldova produce :

(1.) Iron pyrites, generally with an admixture of a little copper, which are used for the manufacture of sulphuric acid.
(2.) Cuprous pyrites with 1½ to 3 per cent. of copper.
(3.) Oxygenated cuprous ores with ½ to 2 per cent. of copper.
(4.) Rich argentiferous lead and copper ores which are forwarded to Dognacska.

Formerly there were several smelting establishments in Moldova ; to-day only one is in a working condition. It consists of one full-sized and two half-sized blast furnaces, and a small refining hearth, and is provided with three water-wheels, the united maximum forces of which amount to ten horse-power.

The large quantity of sulphur contained in the roasted pyrites (about 20 per cent.) as well as in the raw pyritic ores, makes the proportion of copper very low. It would be impossible to arrive in a first crude smelting at a matt sufficiently rich to pass it directly to be fused into black copper, except argillaceous iron ores were admixed to the charge, and this condition cannot be fulfilled on account of financial considerations.

The plan pursued under these circumstances is therefore to produce in a first crude fusion a feeble matt (of only 4 to 6 per cent. contents), to roast this matt, and then to re-fuse it in a second operation to obtain a matt suitable for being worked into black copper.

The crude matt is sufficiently rich in sulphur to be burnt in the sulphuric acid manufactory and thus to save the costs of roasting.

The enriched matt is worked to black copper either at Moldova or at Szászka ; its value bears the expenses of transport.

The smelting operations at Moldova are very similar to those at Szászka, and require therefore no special description ; but the costs are somewhat higher in consequence of the preliminary crude smelting to which the materials have to be submitted.

Among the ores which are derived from the mines of Oravicza and of Csiklova only one part is argentiferous, that coming from the district of Wadarna ; the others contain no silver, and suffer consequently a special treatment. These ores are :

(1.) Copper pyrite ores in a gangue of limestone and quartz, derived from the Tilfa mine and its environs. These contain on the average 2½ to 3 per cent. of copper and give in the assay 11

per cent. of matt (protosulphide of copper and protosulphide of iron). In some specimens the amount of metal rises to 12 per cent.

(2.) Carbonated and oxydized pyritic ores in a quartzose limestone gangue, which also contains garnet; their ratio of metal is about 3 per cent., like that of the above.

(3.) Pyrites in quartzose limestone gangue, with at least 4 per cent. of copper.

All these pyritic ores are converted into ordinary metallic copper at Csiklova.

The first operation is the production of rich matts of about 20 to 30 per cent. copper, which are worked up directly to black copper.

The furnaces employed are the same as those used for the smelting of the argentiferous ores, though they are by no means best suited for the purpose; but the restricted importance of this branch of smelting at Csiklova does not permit the construction of special furnaces.

The crude smelting is effected in covered furnaces of about 12 to 14 feet high, from the bottom to the mouth; the latter is 5 feet wide between the sides, whilst the width of the furnace at the bottom (on the level of the nozzles) is a little over 3 feet. The four walls incline towards one another in the region of the nozzles, and a little above. There is a nozzle on each of two sides of the furnace, about 4½ feet above the bottom, with about 2 inches diameter.

The furnace charge at Csiklova is characterised through an abundance of silica, as compared with the amount of bases present; and in order to render it more basic, limestone is added, or roasted poor matts from previous operations, or ochreous and other ferric ores, or, finally, a mixture of all three is often employed. A portion of the produced matts is put back during the operation, in order to increase in the blast furnace the proportion of sulphides to the slags. The slags formed occupy a middle position between uno- and bisilicates. The proportion of sulphur and of iron to the copper in charge is such as to necessarily insure a rich matt.

The average composition of a charge for 1,000 parts of ores is:

		Copper.
1,000 parts of ores, with 3·04 per cent. copper	.	30·4
70·8 „ rich slags, with 3¾ „	.	2·7
57·7 „ roasted matts, with 21 „	.	12·25
51·6 „ pyrites.		
42·1 „ ochre and iron ores . . .		1·4
197 „ slags of copper smelting.		
8·4 „ slags of the operation		
5·4 „ limestone.		
110·5 „ crude matts of the operation put back into the furnace.		
1595·1 total with	.	46·75

This charge yields:

	Copper.
110 crude matts (to be put back into the furnace).	
196 matts (desired product of operation) with 24·8 per cent of copper	48·60
82 rich slags and cinders, with 3·7 per cent. of copper	3·02
Copper contained	51·62

The costs for this operation are per ton of ore:

	s.	d.
Roasting of the first crude matts . . .	0	4½
Charcoal	12	10
Wages and sundry expenses	7	4½
Total	£1	0 7

The matt obtained in the first crude smelting is repeatedly roasted, and the costs of these roastings are for the ton of crude matt and thin matt together:

	s.	d.
Wood	4	0
Charcoal	2	0
Wages and sundry expenses	2	8
Total	8	8

The roasted matts are fused to black copper in a furnace with a single nozzle, having a height of 12 feet, and a somewhat trapezoidal section. Below the nozzle the section is contracted. The average distance of the walls is 3½ feet at the mouth, and 2 feet 2 inches at the bottom. Diameter of the nozzle and pressure of the blast are the same as in the furnace for the crude smelting.

The roasted matt coming from the crude smelting is treated along with the thin matt derived from similar previous operations.

The charge is composed as follows:

	Copper.
835 parts of roasted matt from crude smelting.	
165 „ thin matt.	
1,000 containing	274·50
259 roasted thin matt	133·00
55 rich slag	4·23
60 quartzose ores	2·59
213 quartz.	
52 siliceous slags.	
1,639	414·32

The yield is:

270·5	black copper, with	92·4	per cent.	metal .	250·00
259	thin matt, „	51·2	„	„ .	133·00
99·5	rich slags, „	16·5	„	„ .	16·40
21	poor slags, „	6·7	„	„ .	1·40
Total					400·80

Consequently there is in this operation a loss of 13·52.

The costs of operating upon a ton of the above mixture are:—

	£	s.	d.
Roasting of about 2,500 lbs. of matt . .	0	10	8
120 lbs. of quartzose ore[1]			
Charcoal	0	13	0
Wages and sundries	0	2	6
Total	£1	6	2

Apportioned to 1 cwt. of copper in the mixture, 9*s.* 2*d.*

The loss of copper has not been taken into consideration in this account, since it is more than compensated by the bonuses of the crude smelting.

The refining of the black copper obtained in the preceding operation is effected in a Hungarian furnace of similar construction to that at Szászka.

The circular bottom, of about 6 ft. diameter, is made of a mixture of clay and crushed quartz. Height in the interior is nearly 3 ft.; distance between the two nozzles, 1 ft. 3 in.; diameter of each of them, 1 in.; normal pressure of blast, ¾ in. of the mercurial column. The fire-place, intended for wood firing, is 7¼ ft. long, 1½ ft. broad, and the grating is about 1 ft. above the bridge.

The usual charge contains 2500 to 2700 lbs. of black copper, and the operation requires from five to seven hours. The furnace can be charged four times in twenty-four hours, and kept going several days without requiring a change of bottom.

The refining of 1,000 parts of black copper, containing 92·4 per cent. of pure metal, yields the following products:—

795 metallic copper.
30 copper waste (Strassen-Kupfer), which is added to the next refining operation.
300 slags, with about 20 per cent. copper, added to the next charge for black copper production.
100 bottom residues with about 5 per cent. copper, put to the next crude smelting charge.

The operation costs:

	£	s.	d.
Charcoal	0	1	5
Wood	0	6	10
Wages and sundries	0	27	1
Total	£1	15	4

Making for 1 cwt. of copper, 3*s.* 9*d.*

In addition to these special smelting expenses, every cwt. of copper has to bear about £1 additional costs, calculated from the general expenditure for the mining district of Csiklova.

The production of ordinary commercial copper at Csiklova costs therefore:—

	£	s.	d.
Crude smelting, per ton of ore . . .	1	0	7
Black copper fusion, per cwt. of copper. .	0	14	4
Refining of the black copper, do. . . .	0	3	9
General expenses of the mining works . .	1	0	0
	£1	18	1

Bringing the total cost of obtaining 1 cwt. of refined copper from the ore to about £5 3*s.* 10*d.*

[1] Merely mentioned for the sake of recalling this addition. Its cost of purchase is covered by the copper (2·59) it contains.

We now come to the treatment of the argentiferous copper ores at Csiklova, which differs from that of the ordinary copper ores not merely on account of the presence of the silver in these ores, but also in consequence of their containing arsenic in a large proportion. The ores consist of pyritic copper, copper sulphide, grey copper, and are mixed with arsenical pyrites and a gangue of garnet, quartz, and crystalline limestone. These ores are separated into three classes, for the purposes of being worked up.

The first comprise the argentiferous ores proper, which contain per ton about 90 lbs. of copper and 7 oz. of silver.

The second class (rich copper ores) comprises all those ores which possess more than 5 per cent. of copper; their average strength is 330 lbs. of copper and 10 to 11 oz. of silver per ton of ore.

The third class (poor ores) consists of ores which contain less than 5 per cent. of copper; on an average there are 90 lbs. of copper and 2½ to 3 oz. of silver per ton of ore. The relation of silver to copper is, however, the same here as in the second class.

The three classes are submitted to the same kind of treatment, but separately. The argentiferous copper obtained from the ores of the first class is always set aside for the purpose of being treated at Moldova, where the separation of the silver takes place. The argentiferous copper got from the ores of the two other classes is likewise submitted to the same treatment, if found to be sufficiently rich in silver; if not it is sold in a metallic state to the engine works at Reschitza, where they use it for bronze castings.

The special feature of all these ores is, as already stated, their containing a large amount of arsenic, for the elimination of which several successive meltings and roastings are required.

The first treatment of the ores, after crushing, is crude melting for the sake of separating the quartz and the gangue, and concentrating the copper and silver in a matt which includes almost all the copper and a large portion of the arsenic of the ore.

This operation is carried on in winter, when the noxious vapours are easier condensed.

Since the ores have mostly an excess of lime, quartz has to be added to the smelting charges.

The melting takes place in a vertical furnace with one nozzle, described above, for the treatment of ordinary copper ores. The two-nozzled furnace is avoided, for the sake of not favouring the liberation of arsenical vapours.

The quantity of ore worked up daily is 5 to 6 tons, and 10 to 12 chargings are usually effected in succession.

The charge is thus composed:—

			Copper.
1000	parts	of ore, 5·42 per cent. of copper	54·2
6·9	„	slags from silver refining	3·2
0·9	„	bottom residues from silver refining	
1·3	„	roasted argentiferous crude melting matts	
31·3	„	dross of argentiferous copper	
157	„	quartz.	
210	„	crude smelting slags, selected from among the most vitreous, as being the richest in silica	7·45
90	„	divers quartzose additions.	
1497·4			57·4

The yield is:

367	parts	of matt, 17 per cent. of copper	62·3
33	„	dross, 2·74 „ „	0·9
			63·2
		Bonus of copper	5·8

The costs of this melting are per ton of ore:

	s.	d.
Quartz	0	10
Charcoal	11	5
Coal, mixed with some coke	0	7
Transport of slags	0	7
Wages and sundries	5	9
Total	19	2

The matts coming from this melting are submitted to 3 or 4 rapid roastings. The chief aim here is the expulsion of the arsenic. The costs of these roastings are:—

	s.	d.
Charcoal	0	6
Wood	1	3
Wages	1	8
Total	3	5

The next following operation is the concentration of the roasted matts. This is effected by melting it again in the furnace it was treated first, mixed with quartz and siliceous slags. The resulting matt is tolerably pure, and well suited for conversion into black copper.

About 7 tons of roasted matts are melted in 24 hours, and about 6 days form a campaign, *i. e.* an uninterrupted succession of chargings:—

The charge is made up of:—

			Copper.
1000	parts	of crude melting matt, 17·1 per cent. copper	171·0
17·8	„	slags from silver refining	10·0
1·4	„	bottom residues	
77·5	„	dross of argentiferous copper	
31	„	ordinary quartzose copper ore	1·1
125	„	quartz.	
15·7	„	siliceous slags from crude smelting.	
6·5	„	divers quartzose additions.	
1274·9			182·1

Products obtained:—

568·9	concentrated matt, 34 per cent. copper	193·5
71	copper dross, 5·9 per cent. copper	4·3
	Total	197·8
	Bonus of copper	15·7

Costs of the ton of matt:—

	s.	d.
Roasting (as above)	3	5
125 quartz	0	7
32 quartzose ores.		
Charcoal	10	9
Transport of slags	0	4
Wages and sundries	6	1
Total	£1	1 2

making for 1 cwt. of copper contained in the matt of crude melting about 12*s*.

The concentrated matts are roasted as completely as possible in 8 to 10 repeated roastings. The costs of this operation are:—

	s.	d.
Charcoal	2	10
Wood	6	0
Wages	3	4
Total	12	2

After these repeated meltings and roastings comes then the smelting to black copper. This operation too is executed in the one-nozzled furnace. The quantity of black copper furnished by the furnace in 24 hours is about 5 tons, and the operations are carried on without break for 6 or 7 days.

The charge is composed as follows:—

			Copper.
989	roasted concentrated matt of 3 classes, 34 per cent. of copper.		336·3
11	matt of the roasted crude smelting, 13·3	„ „	1·5
1000			337·8
153	roasted thin matt, 52·3 per cent. of copper		80·1
73	argentiferous slags from refining		34·0
3	sweepings, dust, &c. of argentiferous copper		
85	argentiferous copper dross		
158	quartz and quartzose additions.		
23	siliceous crude smelting slags.		
1495			451·9

This charge yields:—

374	black copper, 87·5 per cent. of copper		327·5
161	thin matt, 53	„ „	85·5
90	copper dross, 19·13	„ „	17·4
	Total		430·4
	Loss		21·5

The costs for the ton of concentrated matt are:—

	s.	d.
Roasting	16	2
Quartz	0	9
Charcoal	12	6
Transport of slags	0	6
Slags and sundries	7	4
	£1	17 3
Making the cost of 1 cwt. of copper	10	6

The refining of the black copper is, like in all previous cases, effected in the Hungarian furnaces, with this difference however, that the result of the operation is not cast into large cakes but granulated. For this purpose the molten mass of the refining furnace is allowed to flow into a vessel full of water, after having first been intercepted by a flat board, which divided the stream into drops. This division into small shot facilitates the subsequent dissolution in sulphuric acid.

The poor argentiferous copper is, like the copper which contains no silver, cast into cakes, and, as has been stated above, is sold as such.

The following is a specimen of the charge of argentiferous black copper :—

		Copper.	Silver.
1,000 parts of	black copper	828	7·4
19·6 „	rich smelting residues	23	0·4
1·1 „	cupriferous and argentiferous washings		
17·3 „	argentiferous copper waste		
1,038·0		851	7·8

The yield of this is :

532 parts of	granulated argentiferous copper of Csiklova	772	6·7
240 „	„ „ „ Dognácska.		
772			
146 „	raffination slags	108	0·6
32 „	bottom residues		
10 „	cupriferous and argentiferous dust and washings		
22 „	rich smelting residues		
	Total	880	7·3
	Bonus	29	—
	Loss	—	0·5

The costs are the same as for refining non-argentiferous copper, except that the bonus of copper and the loss of silver have to be considered.

The loss of silver in the poorer ores is difficult to estimate. Nothing is paid at the mine for the silver in such ores which contain less than 6 oz. per cwt. of copper, since its price just covers its extraction. It is on account of this circumstance that the amount of silver contained in the poor ores and bye-products is not entered in the official records.

The results of the treatment of good argentiferous ores are however well known. The books of the smelting stations give in the crude smelting a bonus of about 3 per cent. for the silver contained ; in the melting for concentration a loss of nearly 2 per cent. ; in the black copper smelting a loss of near $\frac{1}{10}$ per cent., and, finally, in the refining operation the heavy loss of $6\frac{1}{3}$ per cent.

The bonus in the crude smelting can only be explained by an error in the assay, or by assuming that some of the bye-products added to the charge contain silver and that this has not been estimated. The feeble losses in the subsequent operations are easily understood, if we remember that the temperature in these cases is not too high, and that, besides copper, there are sulphur and arsenic in large proportions present to prevent any inclination on the part of the silver to volatilize ; whilst the considerable loss in the last operation is to be ascribed to the high temperature, which, together with the absence of arsenic and sulphur, facilitates the going-off of the nobler metal.

There is, therefore, on the whole a loss of 6 per cent. of silver, which must not be lost sight of in the valuation of the ores.

The clear costs of the treatment of the argentiferous ores resolves itself to the following items :

	s.	d.
Crude smelting, per ton of ore	19	2

	£	s.	d.
Smelting for concentration, per cwt. of copper	0	12	0
„ black copper	0	10	6
Refining	0	4	2
General mining expenses	1	0	0
Total	2	6	8
or, for 1 cwt. of copper	4	2	6

The granulated argentiferous copper produced at Csiklova is forwarded to Moldova, where the copper is separated from it in the state of sulphate. Formerly the silver used to be extracted from the black copper by amalgamation. The costs for this were about £2 10s. for every cwt. of black copper treated ; wages, prices of charcoal, and wood being now nearly twice as dear, the cost of amalgamation would not be paid by the selling prices. Moreover, the copper was very impure, and there was a loss on it of 10 per cent.

The present process, though attended by a greater loss of silver than that of amalgamation, is nevertheless decidedly more advantageous. But before describing it in detail, we wish to say a few words on the manufacture of the sulphuric acid.

The sulphurous acid required in the production of the oil of vitriol is derived from the roasting of the pyrites above mentioned. The roasting furnace is a long reverberatory furnace divided into three compartments which communicate with one another. They are separated at the height of the grating by a low brick wall which supports a vault, and each of them has an opening in the vault for charging, and two working doors, one on each side of the furnace.

Each compartment is 7 ft. long and 6 ft. wide, and presents therefore a surface of 42 sq. ft. The grating consists of about 40 bars of iron, laid in the long direction of the furnace, and supported by three bars of cast iron fixed about 2 ft. distant from one another. The clear space between two longitudinal bars is 1 in., the breadth of a single bar is likewise 1 in., and its height $1\frac{1}{2}$ in.

The pyrites are reduced to walnut size before being introduced into the furnace. The pyrites powder resulting from the crushing of the ore, is impregnated with solution of iron sulphate and some sulphuric acid and formed into bricks, or lumps of convenient size. Sometimes a little clay is employed for binding the pyrites dust ; this is the more easily done, since no pyritic ore is completely pure ; ore, which contains 25 per cent. of gangue is still considered good.

Poor matt, derived from the crude smelting of cuprous ore, is treated in like manner.

The pyrites are spread on the grating in a layer of nearly 2 in. in thickness. Between two chargings the grating is carefully stoked to clear the interspaces ; the roasted pyrites being generally very brittle, fall easily through. When the clearing is accomplishing, the new charge, which received a preliminary heating on the outside of the vault, is allowed to drop through the top opening, and is then spread with a long iron bar, introduced through the working door.

During roasting the top openings are closed ; the air required for the combustion of the sulphur enters from below the grating ; and, if found necessary, by two square openings at the end of the furnace, on a level with the upper surface of the pyrites layer.

The furnace is charged three times a day, and the result of a day's work amounts to 4,000 lbs. of pyrites roasted, being nearly 100 lbs. per square foot.

The inconvenience of a furnace of this kind is, that the compartments depend too much on one another, they must be at work at the same time. Further, the cleaning of the grating in this system is too troublesome, and to a certain extent even dangerous for the workman. Finally, it is impossible to regulate the quantity of air which ought to pass over the grating.

The increased demand for oil of vitriol having necessitated the erection of an additional furnace, a new system has been tried, which seems to have given much satisfaction in Belgium.

The new furnace is also divided into compartments, to the number of six, but they communicate only at the upper part, which serves for conducting the gases away ; below they are completely separated from one another ; in the former furnace there was also communication below. Each compartment corresponds, on the one side, below the grating by a special door, with a lateral chamber through which the air arrives, and which serves for the passage of the workmen and the carrying off of the burnt pyrites ; on the other side, with a smaller chamber, which, during the clearing of the grating, is set into communication with a chimney. The labour of clearing is under these conditions much better accomplished, and so is the removal of the residues. The closing of the communication doors, which is effected through registers, suffices at the same time to arrest the work of one of the compartments, whilst the other continue in their functions. The charging and spreading out of the pyrites is the same as in the former case.

Every compartment is 6 ft. 9 in. broad, and about 5 ft. long, giving nearly 34 square ft. surface for one compartment, and 204 square ft. for all the six.

Supposing the working capacity of this furnace to be not less than that of the first, there would be daily burnt in them 6,300 lbs. of pyrites, corresponding to a production of 23 cwts. of sulphuric acid of 60° strength ; it is very probable that the roasting capacity is, however, greater.

A disadvantage attending the roasting of pyrites at Moldova is the carrying off of pyrites dust by the sulphuric acid gas. To prevent its entering the lead chambers, a condensing chamber is

inserted between them and the furnace, which chamber contains a dyke, so situated as to break the stream of gas.

The soda nitrate, destined for the libration of nitric acid, is introduced in two cast-iron waggons at the lower end of the vertical shafts which connect the roasting furnace with the lead chambers, or, in the last named furnace, with the condensing chambers; the waggons are introduced through special doors, which afterwards are carefully closed.

The nitrate (containing about 92 per cent. pure nitrate) is mixed with sulphuric acid of 60° strength; each charge consists of 7½ to 8½ lbs. of soda nitrate, and 15 to 16 lbs. of acid; every four hours the charge is renewed. The reaction between acid and salt is effected by the heat of the gases passing the mixture.

There are (or were a few years ago) two lead chambers, with capacities of 11,000 cubic ft. and 46,500 cubic ft. respectively. The two chambers communicate with one another through a lead tube of about 18 in. diameter, issuing from the top of the one chamber, and entering near the bottom of the other; this arrangement permits the retaining of the last traces of pyrites dust in the first chambers.

From the second chamber rises a column of lead of about 40 ft. height and 2 ft. square section, filled with coke. The sulphuric acid collecting here flows back into the first chamber.

The first chamber receives four jets of vapour, the second twelve, through tubes of 1 in. diameter, which are provided with nozzles of ¼ in. diameter.

The chamber acid, of an average strength of 46°, is concentrated in three lead basins, which are on different levels, and communicate through syphons; only the lowest basin yields concentrated acid. The heating is effected through cast-iron plates, which in their turn are heated by the waste flames from the distilling furnace, presently to be mentioned.

These lead basins bring the chamber acid up to 60°, and they concentrate to the strength from 3000 to 3600 lbs. of acid in twenty-four hours.

The acid of 60° is raised to a strength of 66° through being distilled in a platinum still; this still has a capacity of 55 gallons, and produces about 5000 lbs. of acid of 66° in twenty-four hours.

The acid of the first chamber gives in the distillation an abundant white deposit, which seems to be a protosulphate of iron, formed in the chamber from the pyrites dust carried there by the gas. The acid derived from the first chamber, and brought to 60°, is reserved for the work at the mines; the acid got from the second chamber is much purer, and gives almost no deposit.

The above figures relating to the sulphuric acid manufacture at Moldova may most likely be all too low, for there was already some years ago great probability that this branch of the mining establishment of Moldova would extensively develope.

The soda sulphate obtained in the treatment of the nitrate is a not inconsiderable factor in the return of profits of the factory.

After this little digression into the production of the oil of vitriol, we take up again the treatment of the metals.

The granulated argentiferous copper is treated with hot dilute sulphuric acid under access of air; the dissolution goes rapidly forward, and the copper sulphate solution is transferred into crystallizing basins; the residues in the dissolving vessels are silver, some copper, iron, lead, sulphur, and arsenic. The amount of silver in these residues is about 10 per cent.; these residues are forwarded for the definite separation of the metallic silver to Dognácska.

The dissolving vessel is of lead, supported by iron tubes, through which heated gases circulate. The copper granules are spread on a layer of loosely laid bricks, and the dissolving acid is poured from time to time over them; the sulphate solution formed is thus carried off at the bottom, where they issue through a lead pipe into another lead basin. About 260 to 275 lbs. of copper are in this way dissolved in twenty-four hours.

As the dissolution of the copper proceeds the granules become smaller and smaller until they are carried down as dust by the liquid. Every two days a new charge of copper is required.

The liquor accumulated in the second lead basin is permitted to settle, and when all suspended particles have collected on the bottom, the copper sulphate solution, which is rather acid, is drawn off and allowed to crystallize; the crystals formed are from time to time withdrawn and spread on boards. The mother liquors are concentrated, and after a second crop of crystals has been obtained, they are mixed with the sulphuric acid in the dissolving vessel.

The crude copper sulphate crystals are washed with water in a wooden chest lined with lead; this washing has the purpose of removing the adhering free acid, but it carries off at the same time some of the argentiferous residue which got attached to the crystalline deposit; the washwaters are therefore collected, and allowed to settle.

The washed crystals are dissolved in pure water, when the last portions of adhering argentiferous dust are set loose, and fall to the bottom. The total capacity of all the crystallizers, of which there are 24, is 1,600 cubic ft.

The crystallizers are of wood, lined with lead, and containing each of them about sixty lead bars across their width, on which the crystals deposit. The crystallization lasts eight days, and every crystallizer yields about 2 cwts. of crystals of prime quality, and about 130 pounds of crystals of second quality.

After the crystals have been washed they are spread on deal boards in a hot air chamber. The drying lasts three to five days, after which the copper sulphate is ready for the market. It is almost absolutely pure and contains but the merest traces of silver.

The argentiferous residues are of two kinds: (1) a residue of greyish colour, containing 1 to 3 per cent. of silver, and chiefly composed of silica and slag; (2) a brownish-red variety, containing 6 to 13 per cent. of silver, and being made up besides of oxides, sulphides, and sulphates of lead, of antimony, of copper, iron and nickel.[1]

The ores furnished to the smelting works of Dognácska by the mines of the district are—

(*a.*) Argentiferous oxygen ores of copper, possessing in the ton 40 to 60 lbs. of copper and about 10 oz. of silver; the gangue is iron oxide and garnet.

(*b.*) Argentiferous pyritic copper ores, having only about 40 lbs. of copper and 2½ oz. of silver in the ton of ore. Gangue is iron pyrites and garnet.

(*c.*) Poor pyrites with ½ to 1 per cent. of copper, and no silver at all.

(*d.*) Argentiferous copper blende ores, with 20 to 40 lbs. of copper and 12 to 18 oz. of silver per ton of ore. Gangue consists of tremolite, quartz, and garnet, and often a great deal of blende.

(*e.*) Galena, with 200 to 550 lbs. of lead and ½ to 2 lbs. of silver. Gangue the same as in (*d.*) This galena contains also some cuprous pyrites.

(*f.*) Argentiferous lead oxide, with 400 lbs. of lead and 12 oz. of silver.

(*g.*) Lead schlich, coming from the lead stamping and washing mills; they contain on the average 800 lbs. of lead and 20 to 30 oz. of silver.

Formerly the copper ores were separated from the lead ores, and treated for concentration, as in the case described already in the preceding lines; but for the last ten years the following system has been followed:—The cuprous ores are mixed with about their fourth part of lead ores, and this mixture is submitted to crude smelting.

Here is a specimen of a charge:

		Copper.	Silver.
280 parts	of roasted (*d.*) ores . .	4·0	0·22
260 „	lead and copper oxide ores	3·9	0·18
460 „	raw (*b.*) ores . . .	11·2	0·05
1,000		19·1	0·45
130 parts	of dross.		
10 „	quartz.		
900 „	lead smelting slags.		
2,040			

This charge yields—

360 parts	of crude matt	22·0	0·3
13 „	work lead	—	0·06
130 „	dross (passed back into the furnace during the operation).		
„	slags.		
	Total . . .	22·0	0·36
	Bonus	2·9	—
Or 15·2 per cent.			
	Loss	—	0·09
Or 16 per cent.			

[1] Here is an analysis of a specimen:

Silica and slags insoluble in aqua regia . .	22·1
Lead sulphate	22·3
Antimony oxide	18·1
Iron oxide	13·1
Copper, partly metallic, partly protoxide, sulphide, &c.	7·7
Silver	7·1
Sulphur, arsenic, cobalt, &c.	9·6
	100·0

The costs are—

	s.	d.
Roasting of ores	0	9
Charcoal	10	10
Wages	4	10
Various materials	0	9
Total	17	2

The crude matt obtained is worked into black copper, &c., as in all previous cases.

The smelting of the lead ores is, like that of the cuprous ores, accomplished in a blast furnace.

A charge is usually composed as follows :—

		Copper.	Lead.	Silver.
320·0	roasted lead blende ores	—	86·5	0·37
215·0	lead oxide ores	—	47·3	0·17
27·6	raw lead blende	—	9·1	0·03
562·6	lead ores		142·9	0·57
34·5	copper oxide ores	0·7	—	0·02
83·2	raw pyritic ores	1·8	—	0·006
13·7	auriferous schlich from Oravicza	—	—	0·01
131·4	copper ores	2·5	—	0·04
306·0	roasted matt from crude copper ore smelting	16·5	—	0·38
55·6	rich and poor litharge	—	90·1	0·12
62·5	cupellation waste			
90.0	lead dross, roasted.			
208·0	„ raw.			
28·0	pyrites			
10·0	quartz			
923·0	siliceous slags from blast furnaces.			
2177·1	charge for melting	19·0	233·0	1·11

The products of this mixed charge are :

201·0	work lead	—	201·0	0·78
253·5	lead matt	18·6	21·3	0·17
41·5	raw matt, to be put back, after having been roasted to the present charge	1·7	—	0·02
	Slags.			
	Total	20·3	222·3	0·97

This shows the following boni and losses :

Copper :	bonus (equal to 6·8 per cent.)	1·3	—	—
Lead :	„ Loss (equal to 4·6 per cent.)	—	10·7	—
Silver :	bonus	—	—	0·2

The argentiferous lead matt obtained is submitted to cupellation. This operation is conducted in the usual continental furnace, of which we gave already a description (No. 19. Pract. Mag.)

A charge of 1,000 parts of lead matt, containing :

Lead	998
Silver	2·715
Gold	0·001

will yield

		Lead.	Silver.	Gold.
2·67	fine silver.	—	2·67	0·005
18·00	poor lead (reduced litharge)	18	—	—
327·00	impure litharge, to be put back in the smelting operations	461	0·075	—
296·00	cupellation residues, to be put back			
2·07	"Abstrich," to be put back			
1·03	dross			
473·00	commercial litharge	429	—	—
	Total	908	2·745	0·005

which shows 9 per cent. loss of lead, and some little gain in silver and (mere trace) of gold.

The costs are :

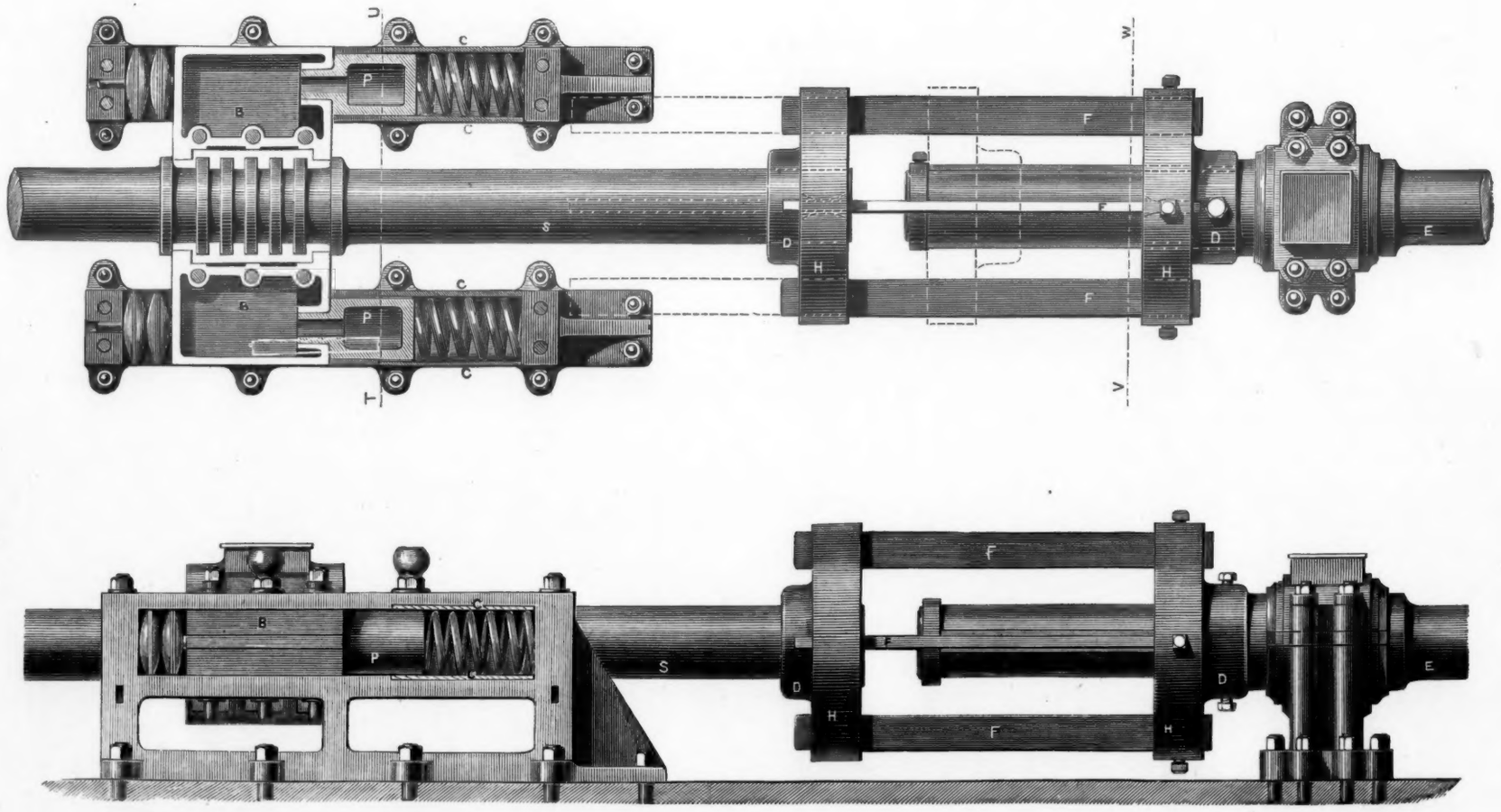
	s.	d.
Charcoal	0	9
Wood	3	0
Wages	8	10
Various materials	1	2
Total	13	9

The argentiferous residues from works at Moldova are melted at Dognácska, with 9 to 10 times their weight of litharge, which melting yields a work lead, containing the larger amount of silver, and dross which is returned in the operations.

ELASTIC SCREW-PROPELLER SHAFT AND THRUST-BLOCK.

THE propulsion of ships by steam power is effected now in a way little thought of by the first advocates of steam navigation. At the outset nothing but the paddle-wheel was contemplated as the mechanical agent, and the screw-propeller remained for some time after its invention in the shade and background of public estimation, the paddle being the favourite. A variety of circumstances combined to retard the universal adoption of the screw-propeller. At the time of its invention steam navigation as a science was in its infancy, and engineers directed all their efforts to the development of paddles and their machinery. Matters are changed now, and the screw is almost invariably applied to steam-ships instead of the paddle. It has a variety of advantages which enable it to compare favourably with the latter; it has also, however, two or three acknowledged defects, which are injurious to the interest of ship-owners. The excessive vibration ever present in large steamers propelled by full-powered engines causes waste of power, discomfort to passengers and crew, and is very destructive to the ship herself, shaking her joints and seams loose, and making a serious addition to the repairs and maintenance bills. From time to time a new form of screw is invented and put forward as one superior to its predecessors in some one point. The engines fitted on board first-class steam-ships during the last few years are, in many respects, models of engineering skill, but in spite of these steps in advance, the vibration evil remains untouched; and besides this, the formation of the shaft uniting the screw to the engines, remains now precisely as it was fitted in the first screw steam-ship, and on this shaft alone depends almost exclusively the safety of the great majority of our largest steam-ships. Many vessels and hundreds of human lives have been lost in consequence of the breakage of screw-propeller shafts. They are made with all the skill and care that can be brought to bear on them, but still they give way occasionally. It seems somewhat remarkable that no attempt has yet been made by engineers to construct screw-propeller shafts in such a way as that, in the event of failure, the fracture might be repaired and the ship brought home. In a word, no attempt is made so to design and construct screw-propeller shafts as that they will be less likely to succumb to sudden strains, or succumbing, shall be easily repaired at sea.

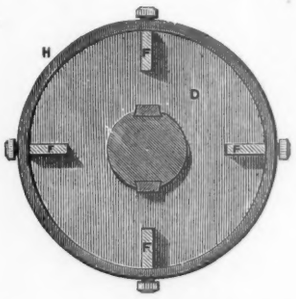
The invention we illustrate at page 149, and devised by Mr. Hamilton W. Pendred, C.E., has been designed with the view of removing, in part at least, the evils commented on above, and to secure also the features enumerated as advisable in propeller shafts. Taking first the invention in regard to the claims of the inventor that its adoption will reduce vibration, these claims are based on the fact that the screw-propeller, as fitted at present, is perhaps the only method of locomotion to be found, either natural or artificial, which is perfectly destitute of elasticity between the motive power and the body moved by it. The vibration of screw-propelled ships is an acknowledged evil, and yet it is one that could be predicted as a certain attendant, not alone on water-borne bodies, but on those moving over or through any non-elastic body. The only attempt ever made to reduce vibration in screw-steamers, has been directed to the fitting of the screw blades to bear on springs in the boss of the propeller; the attempt, however, had to be abandoned, owing to the constant breakage of the blades from the boss. The cause of vibration in screw steam-ships is perceptible enough. A series of rigid iron blades are rotated near the surface of the water, itself quite inelastic and constantly moving in diverse currents; the screw is rigidly united to the ship and to the reciprocating parts of the engines, the three structures being all subjected to a series of strains, crossing and recrossing each other in various directions, and perpetually altering in magnitude. The philosophical manner of meeting such a state of affairs would be to let ship, machinery, and propeller have each some independence of action, easily secured by the interposition of some spring or flexible medium. The reciprocating parts of the machinery have already such independence of the ship's hull directly, but from the fact that they are bound fast to the shaft and propeller, and these again to the ship, no advantage is derived. Few will deny that artificial floating bodies, to be



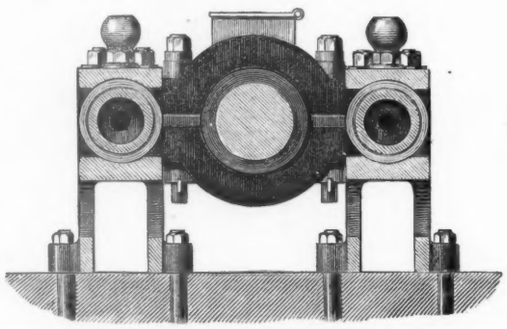
PENDRED'S ELASTIC SCREW-PROPELLER SHAFT AND THRUST-BLOCK.

moved with the best results, ought to embody something of the principles observed in Nature's mechanics, as exemplified in a fish; a salmon, for example, can dart through the water with great velocity and smoothness, and exemplifies the perfection of flexibility.

The invention now under notice is an attempt to introduce elasticity in two directions, crossing each other at right angles, thus securing what may be termed universal elasticity, inasmuch as every movement of the ship will come more or less under its influence. The two elasticities are respectively longitudinal and torsional; the former is obtained by fitting the thrust-blocks, not as rigid fixtures to the ship's hull as at present, but in slides, and bearing against springs. The latter is provided by making the screw shaft separate from the engine shaft, and conveying the rotative power of the engines to the screw shaft through flat flexible steel blades working between a pair of discs placed respectively on the screw and the engine shafts. Referring to the drawings, E is the engine and S the screw shaft; D D' are discs on the shaft, hooped with steel hoops H; that on the engine shaft can be moved along the shaft nearer to or further from the screw shaft; the other disc is a fixture. Each disc has a series of radial notches cut in; only four are shown in the illustration for the sake of simplicity, but any reasonable number can be made. Into these notches flexible steel blades F are passed, and secured in the engine or movable disc by set screws. The reason for making one disc movable along the shaft is to enable the engineer in charge to alter the amount of torsional elasticity, which is of course proportionate to the length of the flexible blades F F between the two discs; one degree of



flexibility may be suitable at one time, and a greater or less degree at another, and when a change in the state of the sea or the immersion or position of the ship as regards the "scend" of the sea appears to call for it, the engineer in charge can, by slacking the set screws shown on the engine shaft disc, release it, and it can then be shifted nearer to, in order to diminish, or farther from the screw shaft disc in order to increase, the amount of torsional elasticity in the shaft. The objection has been raised that the proposed arrangement of a cage of flexible blades cannot be made to combine efficiently, a proper degree of flexibility and at the same time a sufficient margin of breaking strain. The answer the inventor gives to this objection is, first that flexibility is retained by the fact that his arrangement partakes of all the properties of an ordinary multiple leaf spring, without the attendant evil of friction of the leaves on each other, always present in the latter, such immunity being secured by the fact that each flexible blade is independent in its action, not resting on or touching the other; and that as to the question of strength, this has already been sufficiently tested by Mr. Jeremiah Head, who employs a similar arrangement between the fly wheel and the rolls in a rolling mill train, and finds it work well, no failure of the bars occurring, and strains of such torsional magnitude and suddenness as are constant attendants on rolls in iron mills are conclusive tests as to strength, and such strains are at the same time absorbed and returned in proper alternations, and rolls are not broken, as they so often are where the momentum of a heavy flywheel rotating with a great rim velocity is suddenly opposed by the resistance of a heavy bloom introduced between the rolls, no elastic medium interposing. The same class of resistances are present in screw steam machinery, the momentum of heavy piston rods, connecting rods, cross heads, guide blocks, and their fittings, answer, in their action on the propeller shaft, as at present fitted, to the fly wheel on iron rolls, the alternating and irregular resistances of the sea to a screw, at one time rotating nearly in mid-air and then deep beneath the sea, are nearly akin to those opposed and withdrawn with the insertion and return of every plate or bar in the iron rolls. The action of the engine governor is alike in both, only regulating the steam strains, but leaving those due to momentum untouched, therefore the inventor claims that an arrangement proved to be strong and serviceable in one case ought to be so in a parallel one. The influence of the arrangement to reduce a portion of the vibration of the ship may be fairly estimated by the reasons given above, inasmuch as by the introduction of torsional elasticity between the screw and the reciprocating parts of the engine, each has a certain action independent of the other, and even as a carriage spring absorbs and nullifies the jerks and jars due to road inequalities, so the torsional elasticity provided will absorb and nullify a part of the present vibration in the screw steam ship



The second feature in the invention under notice is longitudinal elasticity; it is claimed for this that by giving the propeller an action independent of the movements of the ship in a horizontal direction that not only will such independence supplement the influence of the torsional elasticity to reduce vibration, but that it will likewise augment the ship's speed with a given engine power, on the same principle that when a sailing ship has to be moved a distance in a calm, the crew exert their power in rowing to more advantage when towing the ship, through the medium of her boats and an elastic hemp cable than if exerted on board the ship herself.

Referring to the illustrations and examining the thrust block, it will be seen to have a pair of lugs B B working in guides similar to those of a locomotive piston rod; to each lug is attached a plunger rod or stud P which bears against the springs enclosed in the cylinders C C shown in section to leave the springs visible. The recoil strains due either to stoppage or reversal of the engines, are taken up both by cup washer springs put behind the lugs as shown, and also the inventor contemplates the use of a pair of air cylinders bolted to the guides, in which pistons packed with cup leathers will move and be connected to the block lugs by rods going through the washer springs, the cylinder ends will be closed and fitted with air cocks so made that the outlet can be increased or diminished, but never actually closed. The cup leathers will be fitted to allow the free advance forward of the thrust block but to oppose its return more rapidly than the air can escape through the cylinder cocks. Other advantages claimed for this invention are that for one thing, from the gradual absorption of the strains to which the shaft is subjected there is less chance of the shaft being fractured when subjected to the momentum strains of the reciprocating parts of the engine; at one time working without opposition, when, in heavy weather, the screw is raised out of the water and in another second opposed by a great resistance, caused by the drowning of the screw in the roll of a wave. For another thing, that the shaft having more immunity from vibration, it will be less affected by crystalline deterioration, and will therefore have less need of annealing to restore fibrous toughness.

There is another feature in the invention which is not illustrated because its principle is so simple as to be comprehensible by mere description alone. Comment has been made at the commencement of this article, on the evil that, as screw propeller shafts are presently fitted, no attention is paid to the question of repairing them if broken at sea, and the loss of the ship and all on board is too often the consequence. The scheme advanced now is to make the shaft of a cross section other than circular, save of course in the journals, though even here Mr. Pendred contemplates an oval core hooped with a steel band, believing it improbable that both hoop and core would give way together, no torsional strain reaching the hoop till the core broke, the hoop would form a reserve and if the core broke still it would be rotated through the medium of the hoop. As to the length of shaft between the bearings, he proposes to use shafts either of a square or an oval section and to place upon each a loose steel sleeve when the shaft is first made; in the event of the failure of the shaft anywhere

within the compass of the sleeve, then the engine being stopped the sleeve is to be run up to cover the fracture, secured with a wedge to prevent shifting, and the rotative strain is transferred through the sleeve to the screw part, it is also advanced as an advantage of the square or oval shaft, that even where the shaft gave a jagged and distorted fracture such as precluded the use of the sleeve that still the shape of the shaft would give facilities for repair by clamps and drag rods, such as would at least keep steerage way on the ship and increase the chances of getting her home in safety. Such clamps, &c. cannot well be fitted to circular shafts because no rotation strain can be passed beyond the fracture without the tedious process of chipping key ways.

SUMMARY OF THE MINERAL STATISTICS OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND, FOR THE YEAR 1872.

By Robert Hunt, F. R. S., Keeper of Mining Records.

When the "Mineral Statistics for 1871" were issued, hopes were expressed that the returns for 1872 would be published at an earlier period than those for that year had been, and that the "Statistics" in future,—by the operation of the new Acts relating to mines and collieries,—would be yet more exact than they had hitherto been. These hopes have not, however, been realized. "The Metalliferous Mines Regulation Act, 1872," fixes, unfortunately, the first day of August as the period when the returns of produce are to be made to the inspector, although all the ores raised in the previous year will have been dressed and sampled, and sold many months earlier.[1] This year (1873) many of the returns have not been sent to the inspector from the mines until late in November. This explains one of the causes which have prevented an earlier issue of the "Mineral Statistics for 1872." Again, the Act requires only a return of the *ores* raised. As such a return would not convey any useful information, it became necessary,—in nearly every case,—to obtain either the value of the ores, or their percentage produce of metal. This has occasioned considerable additional labour in visiting the mines, or in corresponding with the managers of mines and others. For the ores raised in Cornwall and Devonshire it has been thought advisable to publish the returns made to the Stannary Court. These, together with the details of the "Public Ticketings" for copper ores in Cornwall and at Swansea, also published, will enable any one to check the estimated quantities of metal produced and the values given.

As it respects coal, it has become a question, seeing how closely the progress of our manufacturing industries are connected with the production and cost of fuel, to determine, for each year, with all possible accuracy, the rate of increase in the production of coal from the collieries of the United Kingdom. Hitherto the quantity of coal raised has been arrived at by issuing circular forms to all the coal owners, requesting a return to the Mining Record Office of the quantity of coal produced from each colliery. These returns have been, generally, freely given, it being always very distinctly understood that they would be treated as confidential and used only to compute the produce of districts. Up to 1871 these voluntary returns formed the basis upon which the returns of coal given in the "Mineral Statistics" were computed. Circumstances, beyond control, in 1871 rendered it imperative to adopt instead the returns which had been made to the colliery inspectors, and these gave a rate of increase above that which was the rate in previous years. Again, for the year 1872, under the operation of the "Coal Mines Regulation Act, 1872," the returns made by the inspectors to the Secretary of State for the Home Department are the sources from which the production of coal given in the following pages are drawn, and the only sources available. The operation of Clause 38[1] of this Act is to limit the examination of those returns to the inspectors and the Secretary of State. Consequently the Keeper of Mining Records has not been permitted to examine them, and he has no means of ascertaining whether or not errors have arisen in making those returns, or in the computation of the aggregates, when they are made. This has been done, in former years, with respect to the returns received by this office, in which errors have been often detected, by visiting the districts, and ascertaining on the spot, from every available source, the correctness or otherwise of the quantities given. The only means by which the Keeper of Mining Records is this year enabled to check the returns as they are now given, is by a cautious examination of the distribution of the coal. This has been attempted on a more extended scale than usual. Returns have been most liberally furnished by the railways and canals; and the quantities of coal exported or sent coastwise have been obtained from the Parliamentary Returns. The value of these tables will be understood by all who thoughtfully examine them.

Summary of Railway and Canal Distribution of Coal in the Years 1871 and 1872.

Railways.	1871.	1872.	1872. Increase.	1872. Decrease.
	Tons.	*Tons.*	*Tons.*	*Tons.*
London and North-Western:—				
From—				
Cumberland	348,668	384,071	35,403	—
Derbyshire	34,355	29,201	—	5,154
Staffordshire	763,738	868,774	105,036	—
Wales, North	391,516	408,667	17,151	—
Wales, South	104,168	107,520	3,352	—
Shropshire	114,586	110,364	—	4,222
Warwickshire	202,379	229,105	26,726	—
Yorkshire	207,962	235,107	27,145	—
Lancashire	5,437,050	5,698,258	261,208	—
Cheshire	141,225	133,014	—	8,211
Midland:—				
From—				
Derbyshire	4,595,527	4,875,044	279,517	—
Durham	165,484	150,990	—	14,494
Lancashire	21,560	22,617	1,057	—
Leicestershire	1,017,201	1,162,087	144,886	—
Nottinghamshire	574,796	689,407	114,611	—
Staffordshire	47,660	53,842	6,182	—
Wales, South	8,345	19,440	11,095	—
Warwickshire	86,826	119,122	32,296	—
Yorkshire	1,503,650	1,637,746	134,096	—
Gloucestershire	234,420	232,875	—	1,546
Great Northern:—				
From—				
Derbyshire	11,419	9,471	—	1,948
,,	375,439	357,580	—	17,859
Durham	511,165	409,414	—	101,751
Leicestershire	1,827	1,231	—	596
Retford	223,420	230,138	6,718	—
Wales, South	—	1,082	1,082	—
Yorkshire, South	801,504	874,620	73,116	—
,, West Riding	490,571	680,068	189,497	—
North-Eastern:—				
From—				
Durham, &c.	10,089,217	10,486,168	396,951	—
Yorkshire and Lancashire	1,064,407	1,134,542	70,135	—
Manchester, Sheffield, and Lincolnshire	3,173,052	3,740,501	566,448	—

[1] "The Metalliferous Mines Regulation Act, 1872."

Clause 10.—"On or before the first day of August in every year the owner or agent of every mine to which this Act applies shall send to the inspector of the district, on behalf of a Secretary of State, a correct return, specifying, with respect to the year ending on the preceding thirty-first day of December, the quantity of minerals sold, or produced from such mine . . . The return shall be in such form as may be from time to time prescribed by a Secretary of State, and the inspector of the district on behalf of a Secretary of State shall from time to time on application furnish forms for the purpose of such return. Every owner or agent of a mine who fails to comply with this section, or makes any return which is to his knowledge false in any particular, shall be guilty of an offence against the Act."

[1] "The Coal Mines Regulation Act, 1872."

Clause 38.—"On or before the first day of February in every year the owner, agent, or manager of every mine to which this Act applies shall send to the inspector of the district, on behalf of a Secretary of State, a correct return, specifying, with respect to the year ending on the preceding thirty-first day of December, the quantity of coal or other mineral wrought in such mine, and the number of persons ordinarily employed in or about such mine below ground and above ground, distinguishing the persons employed below ground and above ground, and the different classes and ages of the persons so employed whose hours of labour are regulated by this Act.

"The return shall be in such form as may be from time to time prescribed by a Secretary of State, and the inspector of the district on behalf of a Secretary of State shall from time to time on application furnish forms for the purpose of such return.

"The Secretary of State may publish the aggregate results of such returns with respect to any particular county or inspector's district, or any large portion of a county or inspector's district, but the individual return shall not be published without the consent of the person making the same, or of the owner of the mine to which they relate, and no person except an inspector or Secretary of State, shall be entitled, without such consent, to see the same."

Railways and Canals.	1871.	1872.	1872. Increase.	1872. Decrease.
	Tons.	*Tons.*	*Tons.*	*Tons.*
LANCASHIRE AND YORKSHIRE	—	2,874,637	100,000 [1]	—
NORTH STAFFORDSHIRE	1,004,049	1,154,723	50,674	—
GREAT WESTERN:—				
From—				
Radstock	306,732	261,657	—	45,075
Wales, South	2,816,825	3,067,685	250,860	—
Do. North	839,090	967,855	128,765	—
Staffordshire for London	1,012	11,446	10,434	—
Do., forwarded	—	494,608	(uncertain)	—
TAFF VALE	3,593,932	4,213,506	619,574	—
MONMOUTHSHIRE	1,741,748	1,759,356	17,608	—
SWANSEA VALE	456,178	494,844	38,666	—
NORTH BRITISH	3,600,618	3,797,249	196,631	—
CALEDONIAN	5,014,894	5,229,093	214,199	—
GLASGOW AND SOUTH-WESTERN CANALS	1,937,177	2,084,894	147,717	—
AIRE AND CALDER	—	—	16,141 [2]	—
GRAND JUNCTION	6,615	8,236	1,621	—
EREWASH VALLEY	1,949,428	2,091,377	141,949	—
BIRMINGHAM CANAL	4,415,697	4,495,333	79,636	—
STAFFORDSHIRE AND WORCESTER CANAL	216,642	214,932	—	1,710
		Total Increase	4,508,183	202,566
		Decrease	202,566	
		Actual Total Increase	4,305,617	

[1] Estimated increase in 1872. No return for 1871.
[2] Computed from actual returns.

Shipments of Coal.

——	1871.	1872.	1872. Increase.	1872. Decrease.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Coal Exported to Foreign Countries	12,747,689	13,198,494	450,505	—
Coal sent Coastwise	10,763,289	10,155,858	—	365,450

Details of Shipments (Coke in all cases estimated as Coal).

From	1871.	1872.	1872. Increase.	1872. Decrease.
NORTHUMBERLAND AND DURHAM.	*Tons.*	*Tons.*	*Tons.*	*Tons.*
Foreign	6,712,757	6,248,304	—	464,453
Coastwise	5,387,412	4,737,178	—	650,234
CUMBERLAND.				
Foreign	3,739	3,288	—	451
Coastwise	599,744	330,425	—	269,319
YORKSHIRE AND DERBYSHIRE.				
Foreign	666,346	824,163	157,817	—
Coastwise	165,720	271,061	105,341	—
LANCASHIRE AND CHESHIRE.				
Foreign	701,255	759,446	58,191	—
Coastwise	642,867	630,232	—	12,635
GLOUCESTER.				
Foreign	12,919	13,953	1,034	—
Coastwise	232,708	344,450	111,742	—
SOUTH WALES.				
Foreign	3,223,944	3,592,767	368,823	—
Coastwise	2,496,711	2,555,805	59,094	—
SCOTLAND.				
Foreign	1,421,516	1,571,934	150,418	—
Coastwise	1,115,598	1,171,396	55,798	—
IRELAND.	2,343	511	—	1,832
PORTS DISTANT FROM COALFIELDS.				
Foreign	106,798	96,230	—	10,568
Coastwise	79,228	120,248	41,020	—
		Total Increase	1,109,278	1,409,492
		Decrease	1,409,492	
		Actual Decrease on those Shipments	300,214	

The difference between this and the 365,450 tons given above arises from the deficiency of returns from some of the smaller ports.

The total increase in the quantity of coal carried by railways and by canals in 1872, as compared with that distributed in 1871, as shown in the returns obtained, is, as stated, 4,305,617. There are some, not very important, lines carrying coal from which returns have not been received; and we have no returns of the quantities carried by carts or private railways or trams, directly from the pit's mouth to the manufactory, or for the supply of towns. This, however, would not appear to have been largely increased over former years. The following computation of the coal used in our metallurgies, which is based upon information received directly from the smelters and ironmasters, shows that in that direction the increase in consumption has been very small:—

Coal used in Smelting, Refining, Desilverizing, &c., of Metals in the United Kingdom.

——	1871. Ore Smelted, and Metal obtained.	1871. Coal used in Smelting and Refining.	1872. Ore Smelted, and Metal obtained.	1872. Coal used in Smelting and Refining.	1872. Increase.	1872. Decrease.
	Tons.	*Tons.*	*Tons.*	*Tons.*	*Tons.*	*Tons.*
BRITISH.						
Tin Ore	16,898		14,266			
Metal	11,320	35,168	9,560	33,500	—	1,668
FOREIGN.						
Tin Ore	562		1,024			
Metal	8,583		8,342			
BRITISH.						
Copper Ore	97,129		90,551			
Metal	6,281	411,912	5,609	379,947	—	31,965
FOREIGN.						
Copper Ore	302,495		317,868			
Metal	23,672		21,788			
BRITISH.						
Lead Ore	93,965		83,968			
Metal	69,056	189,807	60,455	185,762	—	4,045
FOREIGN.						
Lead Ore	20,860		14,560			
Metal	64,908		69,941			
BRITISH.						
Zinc Ore	17,763		18,542			
Metal	4,966	171,920	5,191	199,265	27,345	—
FOREIGN.						
Zinc Ore	29,418		32,662			
BRITISH.						
Iron Ore	16,334,888		15,582,251			
Metal	6,627,179	19,881,527	6,741,929	20,225,787	344,260	—
FOREIGN.						
Iron Ore	524,034		955,032			
Bar or Merchant Iron	5,566,175	18,648,686	5,409,203	18,320,830	—	327,854
			Total of Increase or Decrease		371,605	365,532
			Actual Increase in the Coal consumed in the above Metallurgies in 1872		6,073	

The consumption of coal in the iron manufacture is computed, upon the information furnished to the Royal Coal Commission, at the rate of three tons of coal used, for all purposes, to each ton of pig iron produced. For the year 1872, as will be seen in the "Pig Iron Manufacture Return," the Mining Record Office has sought and obtained, for the first time, returns of the coal used from nearly all the blast furnace establishments. As the result of the economy which has been rigidly pursued since the advance in the price of coal, we have only 51 cwt. of coal given as used for each ton of pig iron produced. This will give the quantity used in 1872 as 17,191,918 tons only. As it is probable that the quantity given in 1871 is in excess, both years have been computed in the table at the same rate, for strict comparison.

The returns of coal produced, as given by the inspectors, differ from those which appear in the "Mineral Statistics for 1872," as shown below, by the addition of the coal raised in Ireland:—

——	Coal raised in the United Kingdom.	Increase.	Coal raised in Great Britain (Inspector's Return).	Increase.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1871	117,352,028	—	117,439,251	—
1872	123,497,316	6,172,288	123,393,853	5,954,602

It has been shown that the increased quantity of coal carried by the railways is above 4,305,617 tons. It is thought, however, that the following estimation, made with great care, will have a very close approximation to the truth, as showing the total increase·

	Tons.
Railways and canals, 1872, increased . . .	4,600,000
Exports, 1872, increased	450,505
Iron and other metallurgies, 1872, increased	6,073
The quantities used at collieries and in mines, estimated increase	10,000
Coal carted or sent by private rail or tram-roads, to ironworks, manufactures, and towns, which does not appear in the above returns, estimated increase	250,000
	5,316,578
Coastwise shipments, decrease . . .	300,214
Actual estimated increase . .	5,016,364

This leaves about 1,000,000 tons of coal to be accounted for, which, out of the large quantity which we are now producing, may appear to be but a small amount. It is, however, hoped that such arrangements will be made in future years as will enable the Mining Record Office to present a yet more closely accurate return of the production and of the distribution of our fossil fuel. To enable this to be properly accomplished, it is hoped that the coal owners will express upon the returns made to the inspectors, their consent, according to the regulation of the Act, that the Keeper of Mining Records shall "see the same," remembering that "the individual return" will be used only, that he, with the sanction of "the Secretary of State, may publish the aggregate results of such returns."

General Summary of the Returns of the Mineral Produce of the United Kingdom received by the Mining Record Office in the Year 1872.

Number of Mines.	Mineral.	Quantities.		Value.
		Tons.	*Cwts.*	£
3,001	Coal[1]	123,497,316	0	46,311,143
266	Iron ore	16,584,857	0	7,774,874
117	Copper ore	91,983	0	443,738
162	Tin ore	14,266	0	1,246,135
455	Lead ore	83,968	3	1,146,165
63	Zinc ore	18,542	12	73,951
35	Iron pyrites (sulphur ores)	65,916	3	39,470
15	Arsenic	5,171	15	17,964
3	Wolfram	88	5	993
1	Cobalt	1	0	20
3	Manganese	7,773	0	38,865
1	Fluor spar	80	12	40
5	Ochres, umbers, &c.	3,326	15	8,227
1	Bismuth ore	2	0	—
1	Chloride of barium	65	0	130
25	Barytes	9,092	17	7,078
	Clays, fine and fire (*estimated*)	1,200,000	0	450,000
	Other earthy minerals (*estimated*)	—		650,000
	Salt	1,309,497	10	654,748
	Coprolites (*estimated*)	35,000	0	50,000
	Total value of the Minerals produced in the United Kingdom in 1872			58,913,541

Metals obtained from the Ores enumerated, &c., in the United Kingdom in the Year 1872.

Description of Metal.		Quantities.	Value.
			£
Pig Iron	*Tons*	6,741,929	18,540,304
Copper	,,	5,703	583,232
Tin	,,	9,560	1,459,990
Lead	,,	60,455	1,209,115
Silver	*Ounces*	628,920	157,230
Zinc	*Tons*	5,191	118,076
Other metals (*estimated*)		—	2,500
Total value of Metals produced from the ores of the United Kingdom in the Year 1872			22,070,447

Total Value of the Metals produced, Coal and other Minerals raised, in the Year 1872.

	£
Metal, value of, as above	22,070,447
Coal ditto	46,311,143
Minerals, earthy, &c.	1,811,826
Total Value . .	70,193,416

The increase in total value, amounting to £12,871,523, is chiefly due to the additional cost in "getting" each ton of coal.

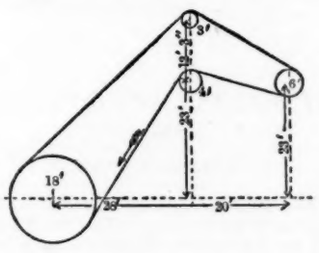
[1] In the evidence given before the Select Committee of the House of Commons in 1873 on "the present dearness and scarcity of coal," it was said that the rise in wages added one shilling and sixpence to the cost of "getting" a ton of coal.

BELTING FACTS AND FIGURES.

THE following facts, taken from communications made in the *Journal* of the Franklin Institute, by Mr. J. H. Cooper, cannot but prove useful and interesting to our readers: "Mr. H. W. Curtis, furnishes the following: We have at our works a 20-inch single leather belt, 167 ft. long, having a 3½-inch single leather belt cemented and riveted on its outside face at either edge, and transmitting the power of a 20-inch diam., 48-inch stroke, horizontal Corliss engine. It is arranged to give power directly to three shafts, each in a separate room, from which the power is further conveyed, by means of vertical belts, to the other parts of the factory. The lower fold of this belt extends from the fly-wheel over a pulley 4 ft. in diameter (see cut), situated 28 ft. from and 23 ft. above the horizontal line of the engine. The upper fold is carried 12 ft. 3 in. higher, and over a pulley 3 ft. in diameter, situated directly above the 4 foot pulley.

The main receiving pulley is 6 ft. diameter, situated in an adjacent building, 48 ft. horizontally distant, having its center on a level with that of the 4-foot pulley.

The fly-wheel is 18 ft. diameter, and runs 60 revolutions per minute, giving a velocity to this belt of 3,392 ft. per minute, and was calculated to give 125 horse-power on the three pulleys



collectively, in the proportion of 80 on the 6-foot pulley, 24 on the 4-foot pulley, and 21 on the 3-foot pully. This would make 70·6 square feet of belt per minute per horse-power on the 6-foot pulley, 235·55 square feet on the 4-foot pulley, and 292·2 square feet on the 3-foot pulley. If considered as a 27-inch belt, it would be working at 61 square feet per minute per horse-power.

This belt has worked up to 125 horse-power, as proved by indicator cards taken from the engine, which subjects the lower or drawing fold of the belt to a tensile strain of 1,216 lbs., or 45 lbs. per inch of width, allowing 7 inches for the 3½-inch strips, making the belt equal to one of a single thickness 27 inches wide.

This belt has been running nine months; its upper fold is very slack, the longest span is 50 ft., at an angle of 45°, having a sag of 20 in. to 24 in., and it has given entire satisfaction during that time. We have also three other belts, with similar strips on their outer faces. These belts were all tried 'single' at first, but would not do the work required of them. The first is 20 in. wide, taking power from a pulley 4 ft. in diameter to 3 ft. in diameter, situated 12 ft. 10 in. directly above. The next is 16 in. wide, taking the greater part of the power from the 20-inch belt, by means of a 40-inch pulley, to one 24 in., situated 12 ft. 6 in. directly above. These belts were put on at the same time as the main belt, and after trying them five days, running only part of the machinery, and that with insufficient power, we thought it best to try the strips. The result was that with the strips they have driven all the machinery connected with them, giving no trouble whatever, and have not been tightened more than once in the time named above.

The next is an 8-inch belt, driving a pump, the piston of which is 4 in. diameter, 12 in. stroke, is double acting, and makes 24 strokes per minute. The pulley on the crank shaft of pump is 22 in. diameter, and this is driven by a 7-inch pulley, situated nine feet below and five feet from the perpendicular line of the pump; both pulleys are covered with leather. The pump lifts water 12 ft., through a 2½-inch pipe, and forces it 80 ft. more of vertical height through 123 ft. of 2-inch pipe.

A single leather belt, 8 in. wide, was first applied, but it would not drive the pump at all. It was thoroughly tried, by being drawn so tightly that it parted at one of the splices in a few minutes. It was then provided with strips, one on each edge, 1¼ in. wide, and put on again, driving the pump success-

fully. It runs about three hours each day, and has not been tightened in five months.

From the above results it is plain to see that our experience with belts of this character has been very satisfactory thus far; and we do think that belts made heavier and stronger on their edges conform to the convexity of pulleys better, and that the same weight of leather will drive more and keep straighter than in any other form. We do not, however, recommend belts, strengthened by narrow strips on their outer faces, for running at a high speed over very small pulleys; in such places only light belts, of an even thickness, should be used."

A Sheet Iron Belt.—A lathe used for turning rolling-mill rolls, compound geared, has a 48-inch pulley on it; this is driven by an 18-inch pulley, on the counter shaft, which makes 120 revolutions per minute, and is 8 ft. from the 48-inch pulley, measured from centre to centre. Both pulleys of iron smoothly turned on faces.

A 7-inch double leather belt was used on these pulleys, but would slip when the turning-tool became dull.

This belt was replaced by one made of Russia sheet iron, same as used for stove pipes and parlour stoves, and was riveted together in the ordinary way; it was seven inches wide and was two inches longer than the leather belt. This extra length made up for the want of elasticity in the iron.

During one year's steady run this iron belt could not be slipped, even when a heavy "cut" on a 25-inch roll was taken, which broke a "Sanderson" steel tool having a section of $2+2\frac{1}{2}$ inches, a cutting surface of $2\frac{1}{2}$ inches, a feed of $\frac{1}{8}$ inch per revolution, and an overhang of 4 inches.

JOHN SPIERS, Worcester, Mass.

SANITARY CARE AND UTILIZATION OF REFUSE OF CITIES.[1]

BY JACOB J. STORER.

THAT the conclusions I have arrived at respecting the proper treatment of animal refuse may be better comprehended, it is necessary that a brief description be given of the most advanced methods now practised.

From most of the packing and slaughtering-houses the blood from the slaughtered animals flows into receiving tanks, whence it is gradually removed to different places to be manipulated for its albumen, or dried for a fertilizer, or some other purpose. In summer the heat causes the blood in these receiving tanks to become offensive in a few hours. Hence the first cause of complaint.

I would recommend that such tanks be made double, the inner one of iron and the outer of wood, and that a space of from 6 to 8 in. be left between the two, which shall be kept filled with ice or shall have cold water constantly flowing through it. This should keep the blood at a temperature at which decomposition and consequent offence would be prevented.

In some cities the blood and much of the offal flows directly into the sewers. Where there is a plentiful supply of water, and the sewer mouths are far enough off, or emptying into a rapid current, there may be but little objection to this plan as far as the city adopting it is concerned, but towns and neighbourhoods along the course of the river, below the sewer mouths, as shown by statistics throughout Europe and this country, suffer to a great degree. To allow this, then, cannot be a good sanitary measure.

The great need of the times is that an economical system be devised, and everywhere adopted and carried into effect, by which tank steam, blood, and tank offal, &c., of packing, slaughtering, and rendering-houses shall be disposed of without violating the laws of health.

Boiling and Fat-Melting Establishments.—The steam and gases from the tanks in which solid animal matter is boiled or steamed, for the purpose of extracting the grease, are perhaps the greatest causes of the offence appertaining to these establishments.

The usual method of conducting the steam and gases through cold iron coils for partial condensation, and making the uncondensed portion pass up through the fires under the boilers, is in most cases ineffectual, for the reason that the boiler fires are rarely, if ever, of sufficient capacity or intensity to decompose and burn all the steam and gases, while that portion of them passing undecomposed or unburned through the coils has its temperature immediately reduced by contact with the heat-absorbing surface of the boiler and escapes with its bad odour into the air.

Where this method is in use the exceedingly offensive condensed steam is generally permitted to flow into the sewers or water-courses, to the detriment of health.

Conducting the steam and gases through heated tubes and then into a good fire is complete and effectual, provided their volume is not in excess of the effective power of the apparatus.

Another plan recently brought into notice is to pass the steam and gases through cold coils, allowing the condensed portion to run into the sewers, while the uncondensed portion is passed through vessels containing lime, for the removal of some of the stench, and thence over naphtha, benzine, or gasoline, for the absorption of carbon, and then is burned as illuminating gas, or carried under the boilers to generate steam.

A portion of the offensive odour in this case is transferred into and concentrated (not destroyed) by the lime, while the rest is rendered inoffensive by burning.

As the uncondensed steam and gases can be properly disposed of without the intervention of lime or liquid hydro-carbons, it is not easy to discover any advantage in their use.

By another method, recently introduced, the steam and gases are blown off into a closed tank, and there condensed to a good degree by copious sprays of water holding in solution sulphate of iron and chloride of lime.

The uncondensed portion, still offensive, is conducted under the boiler fires. The condensed portion is inoffensive, and no objection can be made to its flowing into the sewers.

The filtering of the condensed steam through charcoal or other substances for the purpose of deodorizing it, while the uncondensed is burned, is another method.

There are several other devices, approaching, as these do, the solution of the problem; but it will be seen that no matter what condensation or purification takes place, a large portion still remains uncondensed and offensive, and has to be disposed of.

The Most Effectual Scheme.—The plan I find most effectual and economical is to build a combustion chamber or oven with a deep ash-pit, made water-tight with cement. The roof of this chamber is full of small openings made by leaving 2″ or 3″ spaces between the ends of the bricks. An oven or chamber 4 ft. square, with a roof 4 or 5 ft. above the grate, will suffice for any packing house if the tanks are blown off successively—no two at the same time, no matter how large the escape pipe.

The steam and gases are then blown off through a cold coil; the condensed steam runs into the ash-pit basin, where it is gradually evaporated, and, passing up, is burned by the fire above; the uncondensed steam passes directly up through the fires.

A slight blast keeps the oven always at a white heat, the roof detains the gases and steam until they are thoroughly decomposed and burned, and at the same time serves to concentrate the heat in the oven.

The escaping flame may be utilized for generating steam, heating furnaces, or any other economical purpose. The apparatus is simple and the result is perfect, no offensive odour escaping.

The Disposal of Offal.—The next point for consideration is the care of the tank offal.

A beeve gives 50 lbs., a hog 20 lbs., and a sheep 7 lbs. of this.

In some instances this is thrown into the water-course, in some upon the surface of the ground, or buried in trenches to be got rid of. It is even permitted by the health authorities in some places to accumulate during the winter, when it gives but little or no offence, and be gradually worked up into a fertilizer during that season, while the excess is allowed to remain in decomposing and stinking heaps throughout the next summer until the return of cold weather, when the fertilizer manufacturer gets again to work.

Public health demands that this offal shall not accumulate anywhere, and that the disposal shall be inoffensive, thorough and immediate. The same demand is made respecting the dead animals of the cities, and those dying in transit on their way to them.

Public economy—the agricultural interest—requires the utilization of this material.

My attention was first called to this subject about a year ago, and though it was entirely outside of my legitimate business, I became interested enough to investigate the matter in all its details of defects and needs, and have made extensive and practical experiments and observations for the purpose of discovering a proper system of manipulation.

The importance of the results obtained must be my apology for alluding to the method I have designed and practised.

Of the treatment of the tank steam and gases I have already spoken.

[1] A paper read before the American Public Health Association, Nov. 12, 1873.

I found that the various offal driers in use were slow in action and offensive in operation. That it was most desirable for sanitary reasons that the blood and offal should be dried and rendered inoffensive immediately on their production; that no accumulation of them should be permitted, and that, consequently, for places where much packing is done and for all large cities, driers should be designed and operated of much greater capacity than any then in use.

One Scheme carried out in Chicago.—I designed and erected at the Union Stock Yards, adjoining Chicago, a brick-lined cylinder 20 feet long and three feet internal diameter, having at one end a fireplace and at the other a smoke-stack.

The intense flame of burning pulverized fuel is injected directly into the cylinder, which has a capacity to treat four tons an hour of mixed blood and tank offal. The jet of flame is not only intense but is constant, so that the drying of the material in the cylinder is very rapid.

In the base of the smoke-stack is a gas combustion chamber of the style and dimensions spoken of in the first part of this paper, and a hot fire is constantly maintained therein.

The offensive steam and gases escaping from the cylinder when in operation, pass into this combustion chamber and are there decomposed and burned so completely that no offensive odours escape; while the resulting flame often extends 20 feet up the stack, bringing its fire-brick lining to a white heat. This flame is sufficient to generate all the steam required to run the machinery of the works. That its results were most satisfactory may be judged from the fact that the trustees of the town of Lake, wherein the works are erected, closed all the other offal-drying establishments within their jurisdiction early in the summer, because of the offence they created, but urged that my works should be kept in operation. At the close of the past summer they unanimously passed a series of resolutions thanking me for having conducted the works without creating any offence whatever, and declaring that for years they had not had a season so free from nuisances, and requesting me to increase the capacity of the works in order that the town might be further freed from foul odours and the accumulation of animal refuse.

Dr. Miller, the Sanitary Superintendent, and Dr. Reid, the Health Officer of Chicago, have often visited my works and fully endorse the expressed opinions of the town of Lake authorities.

Encouraged by this action of the authorities, I have arranged to have in operation there in a few weeks another cylinder capable of drying 10 tons of raw blood and tank offal an hour. The machine is 50 feet long by 5 feet in diameter.

A jet of pulverized fuel, constantly burning in the gas combustion chamber in the base of the stack, will insure thorough decomposition and burning of all the offensive gases and steam which must so rapidly escape during the treatment of this large amount of material.

From various causes, lack of co-operation, etc., I have not been able to carry my system into practice in all its details.

Still another Plan.—A further step in this system is the treatment of the tank water or soup.

It is estimated that there are about twelve gallons of tank water, or soup, made per beeve, three gallons per hog, and one gallon per sheep; according to these estimates, there is annually produced in Chicago, and permitted to run into the watercourses and sewers, about 8,000,000 gallons, or 36,000 tons.

It is easy with these figures to arrive at the amount produced in other cities.

This 36,000 tons of tank-water, carries with it to the river not less than 4,000 tons of animal matter in solution, or suspension, after the heaviest particles of matter have been deposited in catch basins.

Some obtained near Boston, and filtered through a charcoal filter, still retained in solution eight per cent. of animal matter in the form of glue. This is exceptional; as a general thing, I think, the animal matter is of such a character as to be easily removed by proper filtration. Many persons have attempted to solve the problem how to separate the animal matter from the liquid, so that only clear water should flow into the sewers.

It appears to me, the best plan in most cases would be to run the liquid, as is now usually done, into catch basins, where the heavier particles of the solid matter will settle, thence into a second series of basins, where still another considerable portion shall be precipitated by chemicals. The soup, now partially cleared, carrying say from five to eight per cent. of solid matter in solution, should be made to flow from the precipitating basins and be submitted to the downward intermittent filtration process, through earth, which has been so successfully adopted for the treatment of the sewage in some towns in England.

I think the adoption of this plan would insure the flow of clear water into the sewers.

In the choice of precipitants to be used in the second series of tanks or basins we should be guided, I think, not only by a desire to obtain an effective precipitate, but also by the cost of the material and the value of the resultant. I suggest that milk of lime be first thoroughly stirred in with the liquid, and that then sulphuric acid be added.

This treatment causes a quicker and more complete precipitation than any I have tried, the resultant contains nothing not of value as a fertilizer, while the cost of the chemicals is fully recovered in the value of the material.

This process is not adapted to the treatment of tank-water containing a considerable amount of animal matter in the form of glue. A proper treatment in such case has, I am assured by Mr. B. F. Shaw of Cambridge, Mass., just been discovered by him and is about being applied at the works of the Boynton Packing Company. He claims to remove all the glue in solution, leaving the water odourless and almost colourless, and that the result of the animal matter removed more than covers the cost of the manipulation.

Pork Packing and Slaughtering Houses.—There is still another point of importance that has received but little attention and which is yet a matter of serious offence from hog packing and slaughtering houses.

From three-fourths of a pound to a pound of blood, bristles, and dirt is deposited in the scalding-vat by each hog scalded. Invariably, I believe, this water with its burden of animal matter is permitted to flow into the sewers. In the presence of so many and great causes of offence, this one has been generally overlooked, yet it requires consideration.

Mr. Shaw designed, and has in operation, at the establishment of the Packing Company above spoken of, a successful method of treating this matter, which I will briefly describe:—

The water for scalding is generally kept at a temperature of about 145° Fahrenheit. When it has become foul and offensive from use, he mixes with it some charcoal dust and allows it to cool down to about 90° Fahrenheit. This is done between the hours of slaughtering. To hasten the cooling, ice may be used. When the water is cooled sufficiently, a quantity of blood, and sometimes a small amount of sulphuric acid, is thoroughly stirred into it, and, after the mass is well mixed, the temperature is raised to boiling point for a few minutes.

The coagulum caused by this means encloses the charcoal and the impurities that were suspended in the water, when they are removed by a skimmer of netted wire.

The water is thus made pure and sweet enough for use again, and may be cleaned and used several times successively.

Mr. Shaw suggests that the scrapings and wash water of these establishments may be collected in vats supplied with steam-heating pipe, and manipulated in the same manner.

It is possible in this way to prevent wholly the escape of blood, manure, and scrapings from the drains of slaughtering establishments. The material recovered from these scalding vats is valuable as a fertilizer, and more than reimburses the cost of the operation.

In most instances the packing, slaughtering, and rendering establishments are *scattered* throughout our cities, each one offending a very considerable neighbourhood, jeopardizing its health, and depreciating the value of the land and houses thereabouts.

Few of the establishments can afford to erect works for drying their offal and blood, or adopt proper means for the care of the tank water, &c. Those who can afford to do so, do not care to add to their other business that of manufacturing fertilizers.

A Good Suggestion.—The removal of these establishments to one location would result in very great pecuniary as well as sanitary advantages to the neighbourhood from which they move; while their assemblage at one place would make it easy for them to adopt a system of management that would satisfy all sanitary conditions. At this place, wherever it might be, one establishment could be erected which should treat all the blood, offal, and tank water each hour of its production. The blood and offal could be hauled to the drying works in covered carts, all offence being prevented by dusting the interior of the carts with powdered charcoal, and covering the tops of their contents with the same, while the tank water could be conducted by sewers into one common reservoir for treatment.

Glue and Bone Works.—Prominent among the nuisances to be found at glue works, is that arising from the heaps of skulls, bones, hoofs and horns, generally piled in the open air till the flesh is removed from them by gradual decomposition. From these arise constantly the most offensive odours. I know from practice a simple and effectual remedy for this nuisance.

Enclose a common house furnace in a brick chamber, the cover or top of this chamber to be made of iron gratings, or perforated plates; on this is built a strong wooden bin with a roof, in which shall be an opening, say two feet in diameter. A fan blower is placed near the top of the bin having both a suc-

tion and force pipe. This bin is filled with these skulls, &c., and fire made in the furnace, the suction pipe attached to the opening in the top of the bin, and the fan put in motion. The heated air is drawn up through the contents of the bin, and with its burden of moisture and offensive gases, is ejected through the force-pipe into the fire. A few hours of this treatment is more effectual than weeks by the present offensive method. The *expense* of establishing new methods has been the principal cause of hesitation on the part of health departments, in enforcing practical improvements.

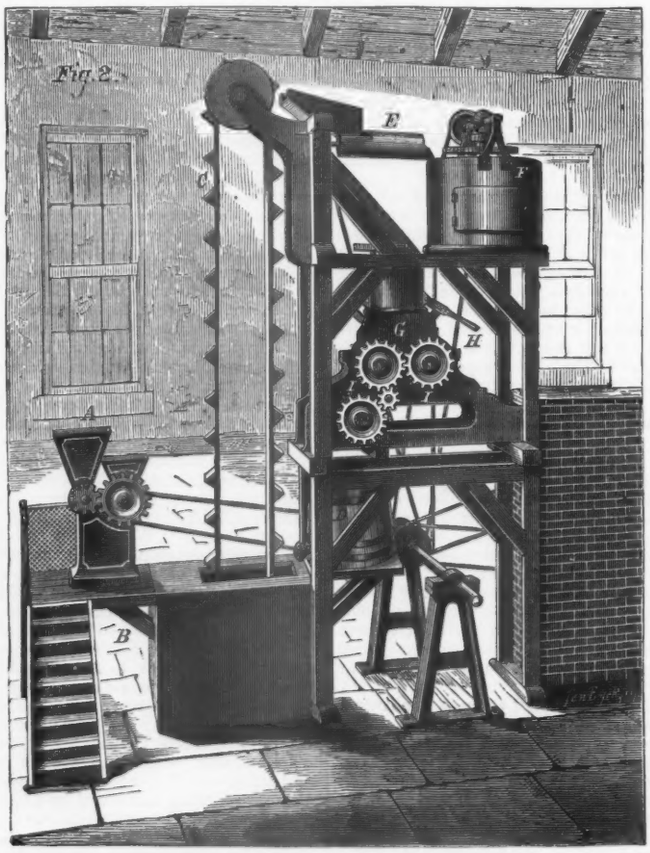
Considering that the element of time enters largely into all practical values, I have endeavoured to show the economy of a rapid and thorough system of manipulation of the animal refuse of cities.

IMPROVED MANUFACTURE OF ARTIFICIAL FUEL.

THE visitor to the coal regions of Pennsylvania, and indeed to all other localities where coal mining operations are in active and continual progress, will not fail to remark the vast heaps of waste or slack piled in the neighbourhood of the mines. It is estimated that, on an average, from 40 to 50 per cent. of the entire yield, both of anthracite and bituminous coal, is, through the medium of mining, breaking, screening, and handling, reduced to this remarkable condition, causing loss to the producer and increasing the cost of the staple to the public.

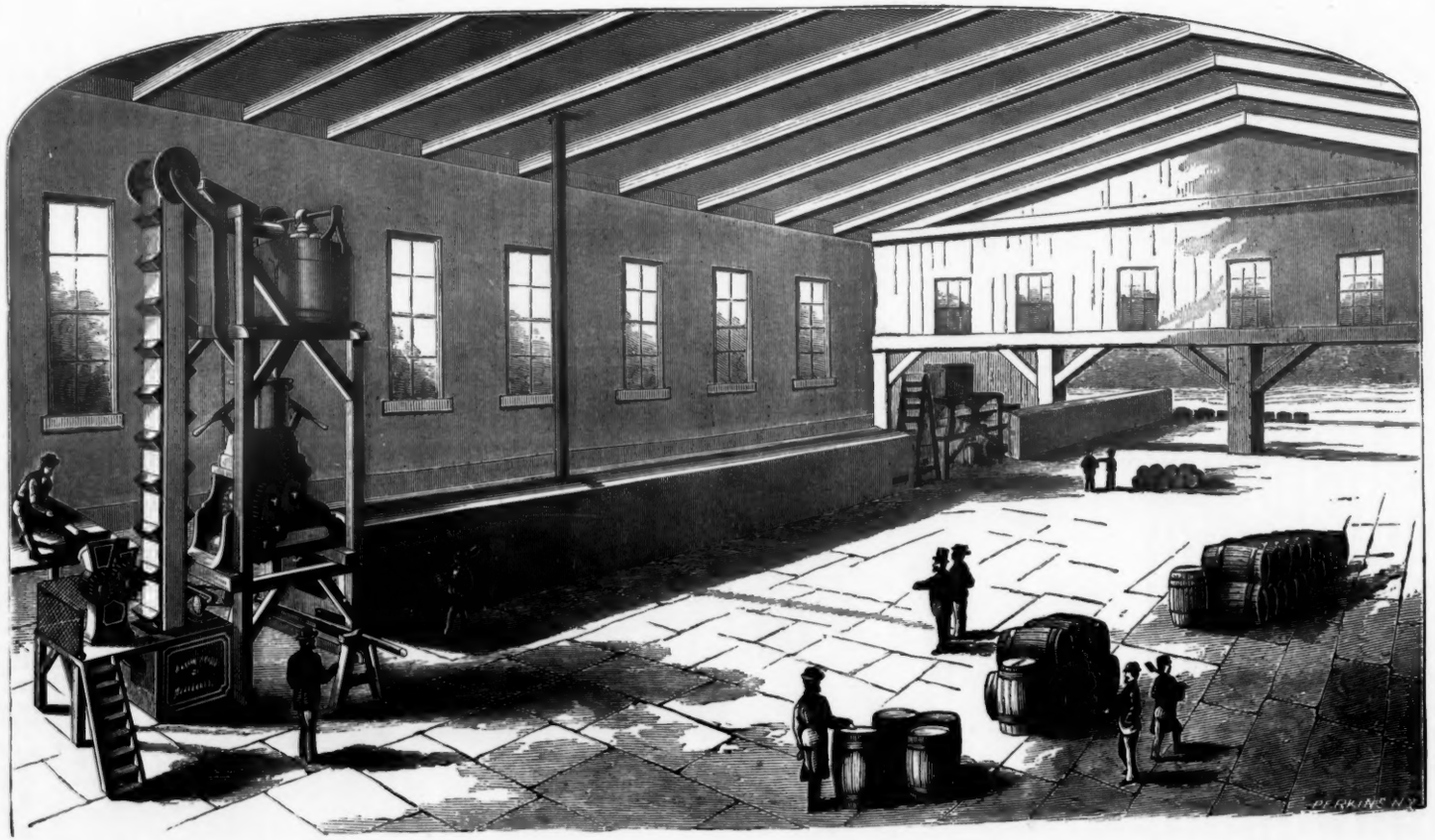
During several years past, various inventions and processes have been devised for the utilization of this waste product through its manufacture into artificial fuel, mainly by combining it with coal tar, pitch, rosin and similar substances. The use of resinous cements rendered the fuel unfit for domestic purposes, on account of its smoke and disagreeable odour; while in employing clay, in connection with these materials, the costly machinery, great consumption of fuel for heating purposes, and extended handling, placed its expense of production too high to render competition with ordinary coal successful. Necessarily, therefore, it has been the aim of the inventor of the machinery and process we are about to describe, to overcome these difficulties; and aided by a long experience in and by a thorough knowledge of the various systems of manufacture as practised in Europe, he has produced a combination of devices which is considered a material improvement on any plan yet invented.

Briefly, the composition of the fuel is coal slack and common yellow clay free from sand, moistened with milk of lime. The manufacture is carried on automatically, the crude materials entering the apparatus at one end and emerging finished and ready for shipment at the other. No labour during the progress of the operation is therefore required, nor does the machine, we are informed, need any attention except to replenish its supply and remove its completed product. Our engravings



MIXING AND FORMING THE FUEL.

give a general view of the apparatus as set up in the factory, and also perspective elevations of its principal portions in greater detail. The entire length of the machine is 218 ft., including two ovens, respectively 100 and 50 ft. long. Referring first to Fig. 2, at A are two hoppers placed above stationary cylinders. Within the cylinder on the left is a horizontal shaft carrying six radial partitions, which divide the interior of the cylinder into as many equal spaces. Into the larger hopper the coal slack is shovelled, and this, descending, fills the spaces between the partitions in succession, and is emptied out as the shaft revolves. The smaller hopper and cylinder are similarly constructed, and are used for the supply of clay. The spaces between the partitions are less in size than those in the coal cylinder, and are so constructed as to discharge regularly 5 per cent. of clay, while 95 per cent. of waste is supplied from the larger cylinder. The mixture takes place in a chute B, which conducts the dry compound under the chain elevator C. At this point the mingled coal and clay is moistened by sprinkling

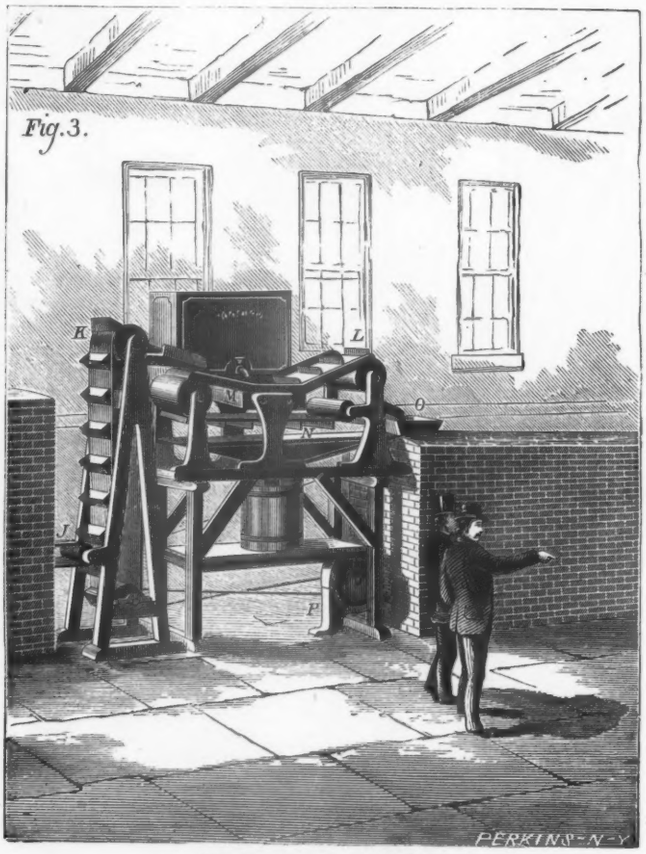


L'OISEAU'S IMPROVED MANUFACTURE OF ARTIFICIAL FUEL.

with milk of lime, or water to which 5 per cent. of lime has been added, the liquid being distributed by the rose nozzle shown on the tank D. The damp compound is now picked up by the elevator buckets and carried up to another chute, whence it passes to a short cylinder E, within which are revolving spiral blades which force it into the mixer F. Inside the latter are arranged seven upright shafts, each one of which carries four toothed arms, crossing each other in all directions. By suitable gearing, these shafts are rapidly revolved, working the compound in the mixer into a plastic mass. An ingenious device allows of the removal of any or all the shafts for repair or replacement without moving the frame on which they stand.

Through apertures in the bottom of the mixer F, the mass next passes to a pug mill G, in which are spiral wings, rotating on a vertical shaft and arranged to force the compound down through an opening at the bottom, the size of which is governed by devices, one of which is shown at H. Leaving thus in a continuous sheet, the mixture is received between two rollers operated by the wheels at I, which rotate in contrary directions. The peripheries of these rollers are indented with molds, oval in form, so that the mass emerges, after pressure, in egg-shaped lumps. It should be noticed that this part of the apparatus constitutes the compressing system, and differs materially in its action from other devices, which aim to drive the mass into its smallest compass by a sudden and heavy blow, often causing breakage of the working parts. Here the water is gradually though rapidly squeezed out, leaving the pieces in compact and nearly dry condition.

Under the rollers is one extremity of an endless belt of wire cloth (not represented), strengthened along its length and at the middle by a wire rope. On the latter are attached cast iron balls, which are so arranged as to secure the wire rope to the belt, and which run in a continuous gutter placed under each portion of the band. The object of the gutter is to carry the weight of the belt, ropes, balls, and coal above, and to support the return portion of the belt below. The balls, as they pass over the pulleys, fit into concave receivers cut into the peripheries of the same, thus insuring the wire cloth from slipping.



WATERPROOFING THE FUEL.

Upon the band thus arranged, the lumps fall, and are carried straight into the first long oven, at the further end of which the opposite belt pulley is placed. At each end of this oven is a furnace by which it is heated. As soon as the lumps reach the end of the upper belt, they are thrown off upon an inclined chute, which conducts them to a second endless band below, upon which they travel back again; thence they fall in a similar manner to a third, fourth, and fifth belts; so that they pass through the oven five times, and over a distance of 500 ft., are subjected to a powerful heat, and finally emerge thoroughly dry.

The extremity of the long oven is represented on the left of Fig. 3, and at J the end of the lowest endless band is seen. This throws its load into the buckets of the elevator K, which carries the fuel to a chute from which it passes to another endless band L. Just above the latter is a tank in which is placed the waterproofing material, a mixture of crude benzine and rosin. The band L, is forced by balls on its sides, acting in grooves, to pass down under this liquid, a quantity of which is drawn, by the faucet shown, into the shallow reservoir M; and partitions are placed along the length of the belt to prevent the sudden fall of the pieces into the mixture and also to carry them out of it. The excess of liquid, which drops from the coal as it emerges from the bath, falls through the wire netting to a gutter N, and hence it is collected in a suitable vessel placed below.

The lumps next fall into the second oven by the spout and hopper at O. Into this receptacle, in order to insure the evaporation of the benzine so as to leave a thin varnish of rosin over each piece, rendering it thoroughly waterproof, a current of hot air is driven by means of the fan blower P. Subject to this powerful blast, the lumps traverse three belts in precisely the same manner described as taking place in the first oven, and finally drop from the last band into an adjustable chute, and thence pass into a coal car placed ready for their reception.

The advantage of this drying apparatus will be appreciated

by comparing it with the labour, necessitated by the European systems, in heaping the large blocks of fuel into perforated cars, by hand, dragging the same into the ovens, waiting for their contents to become almost completely carbonized, then waiting still longer for both cars and load to become cool, when even further handling is necessary to prepare the material for transportation. There is no mixture of resinous matter with the fuel, thus avoiding the loss of cohesiveness due to the consumption of the tar, pitch, or asphalt first taking place, which allows the small particles of coal to fall through the bars before they have given off their full heating power. The waterproofing compound simply forms a light varnish over the surface, which protects the interior from moisture, and, while rendering the handling of the lumps free from the annoyances of dust and dirt, serves also as a kindling material.

At a recent trial of the fuel under one of the boilers, at the present Fair of the American Institute, we were afforded an opportunity to examine its cohesive quality. The pieces were thrown into a furnace where very active combustion was in progress; and although allowed to remain there for a considerable period of time, they did not lose their shape or run together. As regards heating power, the inventor considers the same to be equal to the best coal. No unpleasant odour is given off, there is of course no slate, and we are assured that clinkering does not take place. The ash, being mixed with clay, is heavy; and hence, where the fuel is used for domestic purposes, does not rise in light clouds, covering carpets, furniture, &c., with dust. The oval shape of the lumps is designed to insure a free draft through the interstices. As to cost, the inventor demonstrates that the material can be supplied at about one dollar per ton.

Practical Literature.

RAILWAY SIGNALS AND ACCIDENTS.[1]

THE experience of the past year has made the subject of railway accidents one of so much importance to the travelling public—and in these modern days of cheap and quick locomotion the travelling public means "the general public"—that the author of the present treatise has evidently thought no apology was needed for laying before his readers what he has to say on the subject; saying it without any preface, and simply drawing our attention to its importance by stating that there are annually killed on the railways of the United Kingdom from 600 to 1,000 persons, and more than double that number injured from all causes. The book is divided into four divisions, as follows:—

1. The development and form of signals in use upon railways from the earliest time.
2. The various patents and improvements deserving of note.
3. The practical results of the several systems, deduced from the accidents which have occurred.
4. The consideration of what methods of signalling and working of traffic appear most desirable to insure safety.

From 1841 to 1873, 444 patents were granted for inventions connected with railway signalling, and the most salient of these are described and illustrated at length in part 2; amongst them are many ingenious and complicated arrangements for signals to be actuated by passing trains, but these automatic arrangements have mostly been discarded as being found upon trial unreliable.

John Saxby, in December, 1856, patented his first important invention, which led the way to the present system of interlocking points and signals, and which has been so well followed up. In 1872 Messrs. Barlow and Carr patented an apparatus actuated by electricity, which is so ingenious that we give our author's explanation of it in full:—

"The patents in 1872 were very numerous, but few invite special consideration; a large proportion were for signals and points actuated by electricity, and that by Barlow and Carr may be usefully explained somewhat in detail. Their apparatus is so contrived that the train announces its approach to the signal cabin, that a signal is telegraphed on to the train by the signalman, and the signal so received is repeated back to the signalman. In order to carry out these arrangements there is a warning signal in the signal cabin that the train may announce its approach. This signal is given by the wheels of a train acting upon a contact-making apparatus situated at suitable distance from the signal cabin. The contact-making apparatus is formed by preference of a spring which is pressed down by each wheel of the train as it passes over it, and thereby moving a contact maker. An insulated wire is laid from this contact maker to the signal cabin, and there connected with an electro-magnetic instrument so arranged that the passage of each wheel over the spring causes one stroke to be given on a gong or bell. The signalman being thus warned of the train's approach transmits a signal to a signal instrument on the train. To enable this to be effected there is in the signal cabin an instrument for transmitting the required signal to the train. This instrument is a simple arrangement by which the signalman by a contact maker of the ordinary construction can break or couple-up the current from a battery in the cabin to an insulated wire. This wire is laid from the cabin up to an insulated metal surface placed in the line between the rails at a suitable distance from the signal cabin. The insulated metal surface is not permanently in electric connection with the insulated wire from the signal cabin, but is thus connected at the time that a train moves over it. The insulated metal surface may be a roller supported by a spring, and having a contact maker below it enclosed in a suitable box and coupled-up with the insulated wire from the cabin. In this case a curved metal bar carried by the engine may act upon the roller and depress it, so as to put the roller and bar on the engine in electric connection with the insulated wire, or the insulated metal surface may be a bar fixed parallel with the rail, and a roller or spring be mounted on the engine so that it shall come into contact with it. In this case, in order to put the insulated bar in electric connection with the insulated wire at the time when a train is moving over it, the wheels of the train would act upon and depress another metal bar placed close alongside one of the rails. This bar is mounted on a number of short links, and is held up by a weight or springs. The axis of one of the links forms part of a contact maker enclosed in a box. The contact maker is constructed so that when the bar is held up the insulated wire and insulated bar are not in electric connection with one another; but when the bar is depressed by the wheels the contact maker completes the connection between the wire and insulated bar. The spring or roller which is mounted on the engine, and which comes into contact with the insulated bar, is coupled by an insulated wire to the end of the coil of an electro-magnet forming part of the signal instrument upon the engine. The opposite end of the coil may either be coupled to any suitable part of the engine, so that the connection to earth may be completed through the lines of rail, or the return current may be conveyed back to the signal cabin by a second insulated wire connected like the other wire to a contact maker to be moved simultaneously with the other contact maker and by similar means. The instrument on the engine is made with a movable signal disc, arm, or other contrivance, which remains in its normal position until an electric current passing from the signal cabin to the electro-magnet above mentioned moves it. When the signal disc or arm is in its normal position it represents the signal "stop," and when it has been moved to the other it represents another, "go on." If a current passes through the instrument on the engine, the signal is moved to "go on;" if no current passes through, the signal remains in its normal position and represents the signal "stop." The stop signal carried by the disc or arm is a red glass, and the go on signal a white glass. When the signal disc or arm is in its normal position, the red glass will be seen through an aperture in the front of the casing of the instrument. If the signal disc or arm is moved to "go on," the red glass is moved away, and the white glass comes behind the aperture. The instrument is made so that a lamp may be placed behind the signal disc or arm, in order that at night a red or white signal light may show. In front of the signal is a screen, which, as the engine passes the insulated metal surface before mentioned, is moved away mechanically or electrically by a trigger or spring fixed on the engine, and at the same time a bell is rung to attract the attention of the driver to the signal exhibited. As soon as the driver has seen the signal, he, by depressing a finger-key, replaces the screen in front of it, and in so doing puts back the signal disc or arm (if it has been moved). This putting back the screen may be done either by the engine driver or by an automatic arrangement; but it is preferable that the driver should, as a part of his duty, be required to put the screen back to its normal position. For repeating the signal received in the instrument on the train back to the signal cabin there is on the engine an arrangement that when the disc or arm is moved, a contact is by the movement of the disc or arm caused to be made between the extremities of the two wires, one coupled to "earth," and the other put into electric connection with an insulated wire leading to the signal cabin by means of

[1] *A Treatise on Railway Signals and Accidents.* By Archibald D. Dawnay, Assoc. Inst. C.E. London, E. and F. N. Spon.

apparatus similar to that already described, and situated at a distance of about twenty yards from it and nearer to the cabin to which the train is approaching. In the cabin the insulated wire above mentioned is attached to a similar instrument to that on the engine, so that if the signal disc in the instrument on the engine is moved, the disc in the instrument at the signal cabin will be moved also, and *vice versa*. Thus the signalman at the cabin knows what signal the engine-driver has received. In connection with the instruments in the cabin there may be a register so arranged as to register the signal given by the gong, the signal given by the signalman, and the signal repeated back from the train. This may be a time-register worked by the clock in the signal cabin. The instrument on the engine may also be fitted with a similar register."

In part 3 is given a piece of what may be called representative accidents, that have happened since the introduction of railways, enumerating only those the source of which are beyond doubt.

Part 4 is devoted to our author's deductions and suggestions. He advocates a uniform system of signalling on all the railways, suggesting the semaphore as being the most useful signal, and that the arm governing the down road should be tapered to distinguish it from the one governing the up road, which should remain rectangular ; and in groups the signals should indicate the respective roads they govern by means of letters or figures pierced out of thin metal, and placed as a projection beyond the end of the semaphore. The other suggestions are equally simple.

An appendix contains extracts for the existing regulations of the Board of Trade, the famous letter issued to the railway companies in last November, and the replies thereto, with Mr. Malcolm's able summing up.

The treatise cannot fail to be useful and interesting, not only to railway managers and inventors, but also to those of the general public who take an interest in what concerns their every-day safety and comfort.

Special Correspondence.

PARIS, *July* 24.

Preservation of vines from the *Phylloxera vastatrix*.—Creation of an inland sea in Algeria.—Cloez' process of bone-bleaching.

To the Editor of the PRACTICAL MAGAZINE.

I SEND you a brief notice of certain questions that are at the present moment occupying the attention of practical men in France.

There is scarcely any scientific man here but has something to say about the *Phylloxera vastatrix*, the destructive insect whose development becomes more rapid day by day, and which threatens to become a formidable epidemic danger for a large part of our vines.

In the last session of the Academy held on the 13th of July, M. Elie de Beaumont reported to his colleagues upon the researches made up to the present time, and the varying modes of treatment of infected vines adopted.

1. In the first place, M. de Beaumont read a letter from M. Bourgeois, whose procedure varies in accordance with the proportional development of the contagion. M. Bourgeois' principle is that of "stamping out" the disease by the destruction of each infected stock. But as the root can never be removed absolutely entire from the ground, the uninfected stocks have to be preserved from the insects harbouring among the rootlets of the stock which has been grubbed up. Against these, M. Bourgeois recommends the use of pounded coal. When the *Phylloxera* attacks a stock, it burrows in the earth in a direction which at the commencement follows the path of the tap root, and afterwards the branches of the root, and so on to the rootlets. The vine will be preserved, according to this, if one removes the earth covering the tap root as far as where it begins to ramify, and replacing the earth by a paste formed of coal and oil, for oil may be substituted coal-tar. To preserve a group of stocks, they should be surrounded by a trench, measuring about half a metre in depth and breadth, filled in with the same matters. Where a vineyard has only been partially attacked, the infected groups will be isolated by the ring of coal ; and the diseased stocks grubbed up. The latter should be burnt where dug, in order to guard against the chance of spreading the disease by carrying the stocks across the fields.

2. M. Solacroup proposes the employment of soft soap dissolved in water. This process produced successful results in an experiment made by him in September, 1873.

3. The Sambre and Meuse Mining Company propose a liquid in which are contained solutions of polysulphide of lime, hyposulphite of lime, and sulphate of lime. This fluid acts, without doubt, by the polysulphides decomposed by the action of the carbonic acid contained in the atmosphere. Sulphur is thrown down, and a continuous disengagement of sulphuretted hydrogen goes on.

4. The *Phylloxera vastatrix* has made its appearance in Greece. M. Catzaros, who communicated this fact to the Academy, reports at the same time that he makes use against the insect of an aqueous solution of the sulphate of the protoxide of iron.

5. Having given an account of the various communications received relative to this matter, M. Elie de Beaumont gave his own views on this important question. The process he submitted to the consideration of the committee consists in the employment of snow. After remaining a while on the surface, snow as it melts penetrates into every crevice of the soil, and destroys a great number of noxious insects—why should not the *Phylloxera* be one of these insects? M. Beaumont proposes to collect, before the time of thaw, all the snow received by the vine, and to heap it up above the root of each plant. Two results would be attained. In the first place the melting of the snow would take place much more slowly, and its destructive action upon insect life would be energetic and thorough in the same proportion. Secondly, we should avoid the formation of the little rills, which under the present plan of culture, furrow up the slopes of the vineyard and carry away the fertilizing principles of the snow.

In the same sitting, the Academy heard some observations from M. de Lesseps upon the project of Captain Roudaire to create an inland sea in Algeria. The idea of Captain Roudaire is to fill the waterspaces which form the old basin of Lake Triton, in the south of Algeria, and to pierce the Isthmus of Gabès so as to renew the great and affluent Bay of Triton. Beyond the general interest which this proposal has, in common with every proposal having for its object the facilitation of intercourse, both France and Tunis have an interest in the formation of the bay, as their territories about it are almost equal ; the execution of the project should, therefore, be carried out mutually by the governments of these two countries. So far as concerns France, it was resolved, that on the presentation of the war budget, the Assembly at Versailles should be prayed to grant a credit of 25,000 francs, for the completion of the necessary studies and the travelling expenses of the staff.

The disagreeable odour in the various museums of Paris, particularly those of natural history, arising from osseous preparations preserved in them, as well as their disagreeable brown and greasy appearance, have suggested to M. Cloez the idea of a process of bleaching which he finds perfectly successful, and which he makes public with the precise intention of voiding any claim to patent rights.

The process is a simple one, and consists mainly in placing the bones or any other analogous matter, requiring bleaching, in a bath of spirits of turpentine. If the bath is exposed to the sun, from three to four days will suffice to give the matters submitted to experiment a perfect bleaching, and to deprive them at the same time of any trace of bad smell. The operation is slower if carried out in the shade, but is not less effective. In both, there is one precaution essential to be taken. The objects should be supported on zinc rests, which keep them at about 99 millimetres from the bottom of the bath. This is essential, for the product of combustion due to the oxidation of the essence is a strongly acid liquid, spreading in a shallow layer at the bottom of the vat, and attacking any object in contact with it.

B. P.

NOTE.

IN our article last month[1] entitled, "A Proposal for the Solution of the Suez Canal Question," there was some confusion in the figures of the comparative statement of the proportion which would have to be contributed by the various states of the world for the abolition of the tolls. The omission of the name of Egypt which should have followed that of Denmark in the list of countries occasioned a misplacement of the figures in the columns opposite. With this correction it will be easily seen how the list of countries and the figures should have been read.

[1] See "Practical Magazine," No. 19, July, 1874, page 19.